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Abstract:

Using an exceptionally rich dataset comprising over 1,800 primary schools and nearly 40,000 students from ten francophone Sub-Saharan African countries, this study analyzes the relationship between teacher gender, student gender, and student achievement in mathematics and reading. Findings indicate that being taught by a female teacher increases academic achievements and that both performance and subject appreciation rise when taught by a same-gender teacher. Traditional academic gender stereotypes are prevalent among both male and female teachers. Our findings suggest that hiring more female teachers in Western and Central Africa can reduce educational gender gaps without hurting boys.

Keywords: Gender, Educational quality, Female education, Sub-Saharan Africa, Same-gender teacher, PASEC.

JEL codes: I21, I25, O55, J16.

I. Introduction

In what is sometimes referred to as the 'feminization of education', the share of female teachers on all levels of education has been constantly rising across the globe. This share can be shown to be correlated to the level of economic development of a country. As of 2015, 44.9 percent of primary school teachers in Sub-Saharan Africa (SSA) are women, while this figure is 59.3 percent for all developing countries, and 84.5 percent for developed countries (UNESCO Institute for Statistics, 2017). At early stages of development, due to a gender gap in educational investment that favors boys, the teaching profession is usually dominated by men (Kelleher et al., 2011). As countries develop and incomes rise, the educational sector expands and girls are often able to close the gap. These two phenomena increase both the overall demand for teachers and the supply of qualified females. As a result, more women enter the teaching profession. At the same time, as the private sector expands, more lucrative occupations arise for educated males (compared to females) increasing their opportunity cost of teaching.

In fact, most advanced countries have witnessed two striking reversals in their educational systems since the 19th century. Firstly, female teachers have surpassed male teachers and therefore teaching has become female dominated in both primary and secondary education (Drudy, 2008, Kelleher et al., 2011). Secondly, girls have surpassed boys in school enrollment, achievement, and graduation rates (Goldin et al., 2006; DiPrete and Buchmann, 2013). Developing countries are following similar pathways. As noted in the 2012 World Development Report, rapid progress has been made in narrowing down the educational gender gap in developing countries over the past two decades. Progress in female participation in education is mainly attributed to a rise in the returns to educational investment in girls, the removal of

institutional constraints, and increasing household incomes (World Bank, 2012). In Latin America, the gender gap in school attainment has been reversed starting from the birth cohort of 1967 (Duryea et al., 2007). South Asia and the MENA region, the two regions with the highest gender gaps in schooling until the 1990s, have seen remarkable progress in narrowing down these gaps over the past two decades (Asadullah and Chaudhury, 2009). In contrast, in Sub-Saharan Africa, gender parity has been achieved in some countries, mainly those located in Southern and Eastern Africa, but not in others. In particular, Western and Central Africa remains a region that lacks behind in the empowerment of girls and women and thus deserves particular attention (UNDP, 2016). According to Grant and Behrmann (2010), this region featured the highest educational gender gap among all world regions during the 2000s. Moreover, its share of female teachers is significantly lower than the average share for Sub-Saharan Africa.[1]

These global trends have sparked two lively public and academic debates: (1) the debate on the relative effectiveness of female vs. male teachers, and (2) the debate on whether the expansion of female teachers can account, in part, for the reversal of the educational gender gap. While plenty of empirical evidence exists for advanced countries, only few studies have been carried out in developing countries so far.

As for the first debate, a growing number of studies has analyzed the relationship between teacher gender and student achievement recently. These studies differ strongly in the type of data used, their availability of control variables, and in their findings.

Some studies suggest that female teachers perform worse compared to their male colleagues, particularly in mathematics: Dee (2007) finds for US data that female teachers perform worse in math, but acknowledges that this could be due to the fact that they were

assigned to lower-performing classes. Warwick and Jatoi (1994) find significant negative effects of female teachers on grade 4 and 5 students' math achievements for Pakistan. However, this early study might have been affected by the shortage of available control variables. Michaelowa and colleagues, in their studies of earlier PASEC data from the second half of the 1990s for five and eight francophone Sub-Saharan countries, respectively, find mixed results on teacher gender: While Michaelowa (2001) finds that female teachers have a negative effect on fifth graders' combined math and French test score, Fehrler et al. (2009) finds moderate positive effects. One should note, however, that neither of the two studies particularly focuses on gender aspects.

Other studies find positive effects of female teachers on student achievements: Muralidharan and Shed (2016), using panel data from Andhra Pradesh, find that female teachers are better in teaching girls than their male colleagues and no worse in teaching boys. Rawal and Kingdon (2010) show for primary schools in rural Uttar Pradesh and Bihar that female teachers outperform male teachers. Further evidence that female teachers perform better in India has been provided by Chudgar and Sankar (2008), who find for five Indian states that being taught by a female is advantageous for language learning. Winters et al. (2013), using panel data from Florida, find small positive effects of being assigned to a female teacher in middle and high school. Neugebauer et al. (2011), in their study of grade 4 students in Germany, find that female teachers increase student achievement when the same teacher was kept during all four years. Moreover, a study of student-teacher relationships using Dutch data finds that female teachers have better relationships with girls than their male colleagues and no worse relationship with boys (Spilt et al., 2012).

As for the second debate, there is a popular belief that girls perform better under female teachers whereas boys show better outcomes under male teachers. This is sometimes referred to

as the “same-gender teacher effect”. In many advanced countries, this belief has led to calls to increase the low share of male teachers, particularly in primary schools (Skelton, 2002). In the academic literature, usually two theoretical explanations for the same-gender teacher phenomenon have been proposed: role model effects and stereotyping.[2] First, it is believed that same-gender teachers can act as role models, enhancing students’ motivation and learning outcomes. Second, teachers play an important role in creating a classroom environment that either fosters gender equality or discrimination. Studies show that traditional academic gender stereotypes such as “males are good at math and females are good at reading” can lead to female anxiety towards math and to biased evaluation of teachers (Beilock et al., 2010; Gunderson et al., 2012).

Findings from empirical studies that have analyzed the same-gender-teacher-nexus are mixed. Dee (2005, 2007) shows for US data that teachers have perceptions about student performance and engagement that are often biased towards their own sex, race, and ethnicity. He finds that student assignment to a same-gender teacher significantly improves the achievement of both girls and boys as well as teacher perceptions. Same-gender effects on student performance have also been found to be significant in the case of India by Rawal and Kingdon (2010) and Muralidharan and Sheth (2016). However, rather limited effects of same-gender teachers have been found in some other, often more advanced countries (Holmlund and Sund, 2008; Cho, 2012; Spilt et al., 2012). Finally, a number of studies from the Netherlands, the US, and Germany have found no evidence that would support the existence of same-gender teacher effects (Neugebauer et al., 2011; Winters et al, 2013; de Zeeuw et al., 2014; Antecol et al., 2015; Coenen and Van Claveren, 2016).

As for Sub-Saharan Africa, to the best of the authors knowledge, only one earlier study has examined effects of teacher gender on student achievement. Kuecken and Valfort (2012) use the second round of SACMEQ data collected between 2000 and 2004 for eleven Southern and Eastern African countries. The SACMEQ dataset is similar in its cross-country nature and design to the PASEC dataset (for ten francophone countries in Western and Central Africa) that we use in our study. Kuecken and Valfort find that both boys and girls perform better with a female teacher in reading, however, that the reverse is true for math. The authors conclude that the traditional academic gender stereotype plays a dominant role in Southern and Eastern Africa.

This article's main objective is to study the relationship between teacher gender, student gender, and student achievement using the exceptionally rich data provided by the "Program on the Analysis of Education Systems" (PASEC) for ten francophone countries in Western and Central Africa. Our study's main objective can be subdivided as follows: (1) to identify the effect of teacher gender on primary education outcomes; (2) to examine the interaction between student gender and teacher gender and its impact on student achievement and subject appreciation; and (3) to provide updated evidence for educational gender gaps and the role of stereotyping for Western and Central Africa using most recent data.

This article contributes to the existing literature in the following ways: First, to the best of the authors' knowledge, this is the first article to take a gendered view on school achievement in Western and Central Africa. Second, this article contributes to the literature on the same-gender teacher effect, a literature which so far lacks evidence from developing countries. Third, it further contributes to the debate on the relative effectiveness of female versus male teachers and can potentially provide valuable policy recommendations for PASEC member countries. Fourth, in contrast to many existing studies that focus only on a single country, this article, by drawing

on PASEC data spanning ten Sub-Saharan African countries, is one of the largest gender-education studies carried out to date. PASEC 2014 data represents the most up-to-date and comprehensive survey on educational quality in the SSA region. Therefore, this study helps to update our understanding of educational gender gaps and the determinants of educational quality in Africa. Lastly, this study applies a state-of-the-art estimation approach by using a two-level random intercept model.

The remainder of this article is organized as follows. Section II introduces the reader to the empirical strategy used to identify student-teacher gender effects and interactions. Section III presents the PASEC dataset and descriptive statistics by teacher gender and student gender. Results and extensions to the main analysis are then presented in section IV. Section V concludes the study by summarizing its findings and discussing relevant policy implications.

II. Gender effects and student achievement – empirical strategy

A simple empirical strategy to model student achievement is an OLS model that accounts for clustering of standard errors by school (Neugebauer et al., 2011; Kuecken and Valfort, 2012). The achievement of student *i* in school *j*, denoted as Y_{ij} and measured by the student's reading or math test score, can be modeled as follows:

$$Y_{ij} = \beta_0 + \beta_1 s\_female_{ij} + \beta_2 t\_female_j + \beta_3 samegender\_fem_{ij} + S_{ij}'\pi + E_j'\theta + C_j'\delta + e_{ij} \quad (1)$$

In equation (1), s_female_{ij} is a dummy variable that takes the value "1" if student *i* in school *j* is female. Analogously, t_female_j denotes whether the teacher of the students sampled from school j is female.[3] The interaction term $samegender\_fem_{ij}$ will be key for our research question. It will allow us to isolate the effect of a same-gender teacher on school performance. The richness of PASEC data allows including a broad set of control variables: S_{ij} is a vector of student characteristics including information on age, pre-school education, grade repetition, family literacy, language spoken at home, and availability of books at home. E_j is a vector of variables related to teacher/ class/ school background.[4] Teacher background includes education, training, experience, job status, net monthly salary, existence of other job, absence record, whether teacher met with parents and other colleagues, whether teacher uses local language or French in class. Class background includes the availability of French and mathematics textbooks, whether students are allowed to take these textbooks home, a teacher resources index, class size, and class hours. School characteristics included are school size, whether the school is private or public, whether it is located in urban or rural area, gender of school principal, average teacher absence rate, access to electricity, and an overall school infrastructure index. Vector C_j represents a vector of country dummies accounting for the country in which school *j* is located.[5]

For OLS results to be unbiased and efficient, the error term e_{ij} needs to be well-behaved. Traditional OLS estimation would falsely treat students as independent observations. However, given the usual sample design in educational data, student performance is likely to be correlated across individuals from the same school. Thus, failing to account for hierarchical structures and the clustering involved can bias standard errors downwards, leading to incorrect inference. Fortunately, there are ways to solve this problem. A first, simple way is to estimate equation (1) with OLS using standard errors that account for clustering at the school level (Neugebauer et al.,

2011; Kuecken and Valfort, 2012). While this is a straightforward strategy to correct standard errors, it cannot account for potential bias on slope parameters caused by unobservable school heterogeneity. A second option would be to add school fixed effects to the model as done e.g. by Dee (2007) and Antecol et al. (2015). However, particularly for very large datasets such as PASEC data, this would require adding approximately 1,800 dummies to the model which is both computation-intensive and leads to a substantial reduction in the degrees of freedom. A third option is to use a multilevel model approach as done by Warwick and Jatoi (1994), Michaelowa (2001) and Fehrler et al. (2009). Multilevel models recognize data hierarchies directly by allowing for residual components at each level of hierarchy. In our case a two-level random intercept model can be specified in which students are the first level (main unit of analysis) and schools are the second level. The error term would then be split up into a between-school component (variance of school-level component) and a within-school component (variance of student-level component). This model has advantages over the earlier two options. First, accounting for unobservable school characteristics in the random error component, each school is assigned an individual intercept which should improve the accuracy with which all other (slope) parameters are estimated. Second, compared to an OLS model with school fixed effects, the multilevel model has the advantage that it saves substantial degrees of freedom and thus improves the estimation. Third, beyond providing a more efficient estimation strategy for PASEC data, the two-level random intercept model can also help the researcher in answering additional research questions. The model allows to identify the relative contribution of school-related factors to the total variation in student performance after controlling for a set of included control variables.

Therefore, given the structure of PASEC data, we specify a two-level random intercept model as follows below[6]:

$$Y_{ij} = \beta_0 + \beta_1 s\_female_{ij} + \beta_2 t\_female_j + \beta_3 samegender\_fem_{it} + S_{ij}'\pi + E_j'\theta + C_j'\delta + u_j + e_{ij} \quad (2)$$

$$e_{ij} \sim N(0, \sigma_e^2)$$

$$u_j \sim N(0, \sigma_u^2)$$

In equation (2), the error term has been partitioned into a school-level component, u_j, and a student-level component, e_{ij}. Both are random components that follow a normal distribution. Note that this model is called the "random intercept model" because for each school the intercept is now $(\beta_0 + u_j)$, which includes a fixed and a random part. The model in equation (2) can be estimated using maximum likelihood estimation.

Non-random assignment of students to teachers based on unobservable characteristics can present a problem for the identification of teacher value-added estimates. If better-performing students were more likely to be assigned to teachers of a particular gender, this might bias the coefficients of β_2 in equation (2).[7] Since PASEC data is cross-sectional and only observes one class and one teacher for each grade and school, unfortunately it is not possible to directly address this issue in our estimation strategy. While this could pose a potential challenge to the estimation of β_2, we are confident that our model remains valid for the following two reasons. First, given the exceptionally rich nature of PASEC data, the likelihood of a potential bias caused by unobservable factors can be minimized by controlling for a broad set of observables in the estimation. Indeed, besides teacher, classroom, and school characteristics, we are able to account

for a broad set of observable student characteristics, including student's age, gender, and educational background (preschool, grade repetition), family educational background (literacy of family members, language spoken at home, availability of books at home) and student's degree of involvement in labor activities. Second, past evidence suggests that female teachers tend to be assigned to classes with *lower*-achieving students compared to their male colleagues (Dee, 2007; Kalogridis et al., 2013). If this holds true also for PASEC countries and we were to find a positive, significant coefficient of $\hat{\beta}_2$, then our results can be regarded as lower bounds of the (positive) effect of female teachers on student achievement. In fact, within the schools of our sample we see certain evidence that women tend to be assigned to lower-level classes within the same schools: While 46 percent of students in grade 2 are assigned to female teachers, this figure is much lower (23 percent) for students in grade 6.

III. Data and Descriptive Statistics

III.1 PASEC data

The data used in this article comes from the Programme d'Analyse des Systèmes Educatifs de la CONFEMEN (PASEC) conducted in 2014. PASEC 2014 is an initiative of the Conference of Ministers of Education of francophone countries (CONFEMEN), aiming at improving their education systems' quality, efficiency and equity by analyzing key school and extracurricular factors. Since its launch in 1991 at CONFEMEN in Djibouti, PASEC has been carrying out national evaluations in over 20 African and Asian countries, which share similar education systems rooted in their common French colonial history.

The 2014 PASEC data is the so-far largest international learning assessment conducted in francophone African countries. It was conducted in Benin, Burkina Faso, Burundi, Cameroon, Chad, Congo, Côte d'Ivoire, Niger, Senegal and Togo[8]. Across these ten countries, almost 40,000 primary school students were surveyed in over 1,800 schools (8,682 grade 2 students and 31,213 grade 6 students). PASEC data offers a high level of comparability and standardization.

PASEC data was collected based on a stratified three-stage simple random sampling design which ensures nationally representative samples for each country.[9] The assessments given in the study tested students' numeracy and literacy skills with standardized procedures and instruments in the country's official language(s) of instruction.[10] For grade 2 students, tests were administered face-to-face with students answering questions orally with very short answers. In case of grade 6 students, "pencil and paper" tests were administered collectively in each class. Test scores were reported for two subjects, reading and math. In addition, detailed information was collected on a variety of student, teacher, classroom, and school characteristics. Tests and questionnaires are standardized across all participating countries, so as to ensure highest comparability.

III.2 Overall sample summary statistics

Table A2 in the appendix summarizes the overall PASEC 2014 sample and provides a detailed description of variables. Math and reading test scores have been standardized at a mean of 500 and a standard deviation of 100. The sample of 2nd graders is roughly balanced in terms of student and teacher gender. This, however, is different for 6th graders where only 23 percent of

teachers are female. It is a common phenomenon found in earlier studies that female teachers are often assigned to lower-level classes (e.g. Dee, 2007; Kalogridis et al., 2013).

Approximately 35 percent of schools in the sample are located in urban areas and about four out of five schools are public schools. Average school size is 402 for the grade 2 sample and 417 for the grade 6 sample. Average class size is 49 in grade 2 and 40 in grade 6. Only 17-20 percent of schools have access to electricity. In grade 2, 81 percent of students have a literate family member, while this figure is substantially higher for those who are enrolled in grade 6 (95 percent). More teachers in grade 6 (88 percent) hold a professional degree than their colleagues in grade 2 (76 percent). Grade 6 teachers have on average 12 years of teaching experience, while grade 2 teachers have been teaching only for about 8 years.

III.3 Descriptive statistics by student-teacher gender combination

For the purpose of this paper, it is advantageous to investigate summary statistics by teacher-student gender allocation. Tables 1 and 2 present the PASEC data grouped into four sub-samples according to the four possible gender combinations.

Table 1 explores summary statistics for grade 2 students. In terms of student achievements in both reading and math, students that are taught by female teachers outperform those taught by male teachers. When taught by a male teacher, the average reading (math) score is 487 (488), which compares to 516 (515) when taught by a female teacher. Part of this gender gap in teacher performance can be explained by the fact that women are more likely to teach in urban areas which are more affluent, have more educated people, and provide better education

infrastructure. In fact, the share of female teachers that teaches in urban schools (47 percent) is almost twice as high as the corresponding share for male teachers (25 percent). Interestingly, and in line with the same-gender teacher effect, girls seem to benefit more from a female teacher than boys. When taught by a woman, girls score on average 31 (30) points higher in reading (math), which is higher than the boys' increase of 27 points in reading and 24 points in math.

[Table 1 about here]

[Table 2 about here]

A similar breakdown of summary statistics for grade 6 students can be found in Table 2. Students taught by females outperform those taught by males. The average achievement gap between students taught by females and those taught by males was 26 points in reading and 50 points in math. However, for grade 6 students the explanation is not as straightforward as for grade 2 students because the gender gap in urban school affiliation of teachers is much smaller now: 36 percent of males and 33 percent of females teach in urban schools. There are, instead, a few other apparent differences between classes taught by males and females. First, the likelihood that the school principal is a female is 5-times higher when the teacher is a woman. Having a female principal and the share of female teachers in a school are two factors that seem to reinforce each other. Second, women are more likely to teach in public schools, and consequently less likely to teach in private and community schools. This might also explain why the schools that female teachers work at are less likely to be electrified. Third, women teach larger classes but are less likely to teach multi-grade classes. Table 2 further presents estimates for students' appreciation of math and reading. Surprisingly, while students score much higher

when taught by a female compared to a male teacher, their appreciation of the subject only slightly rises in case of reading, and actually falls in case of math when taught by a woman.

III.4 Teacher perceptions and actual performance of boys vs. girls

As described recently by Gunderson et al. (2012), teachers play a key role in transmitting gender-related attitudes towards particular school subjects. Along with parents, teachers are the ones that determine to what extent traditional academic stereotypes such as "males are good at math and females are good at reading" are passed on to future generations. Table 3 provides stereotype-related information from PASEC surveys. For our grade 6 sample, it compares teachers' perceptions of the average relative performance of girls vs. boys in their own class with those two groups' actual relative test scores. The statistics help provide a better understanding of the underlying drivers of gendered school performance and the role of stereotyping.

[Table 3 about here]

First, Table 3 reaffirms the point made in the interpretation of Tables 1 and 2 that the same-gender teacher effect matters. When classes were taught by male teachers, boys on average outperformed girls in math tests in 65 percent of cases and in reading tests in 57 percent of cases. In contrast, when classes were taught by female teachers, the reverse was true; girls outperformed boys in 59 percent of cases in math and 58 percent of cases in reading. Interestingly, however, teacher perception about sex-specific student performance differs substantially from actual performance of girls vs. boys. Boys are perceived a lot better in math than girls by both male and female teachers. This stands in stark contrast in to boys' actual math

performance relative to girls in classes with female teachers. In case of reading, male teachers perceive boys slightly better than girls. In contrast, female teachers perceive girls substantially better than boys. This clear lack of congruency between actual and perceived performance of boys versus girls is a clear sign of profound stereotyping that continues to be deeply rooted within Sub-Saharan African educational systems.

IV. Estimation results

IV.1 Grade 2 students

Table 4 presents the results of estimating the determinants of reading and math test scores for grade 2 students as modeled in equation (2). The maximum sample size comprises 8,657 students in 931 schools across the ten PASEC countries. All models account for country-level fixed effects and school-level random effects (random intercept). Columns (1) and (4) suggest that, after controlling for country and school effects, female gender of student is negatively and statistically significantly related to reading and math performance. Not surprisingly, the gender performance gap is higher in math than in reading. In addition, the models suggest that female teachers have a significant positive effect on learning outcomes. Findings also suggest that student performance strongly varies by country and school.

[Table 4 about here]

In columns (2) and (5), controls for student characteristics, teacher characteristics, class and school characteristics have been added to the model. Interestingly, adding all these controls

does not affect the student gender performance gap, which has roughly kept its size. In contrast, the teacher gender performance gap has now shrunk to about one third of its initial effect in columns (1) and (4). Nevertheless, it is still positive and statistically significant implying that female teachers improve educational outcomes.

The same-gender teacher effect (*samegender_female*) is added to the models in columns (3) and (6). It is positive and significant indicating that same-gender teacher does play a role for grade 2 students in PASEC countries. Coefficients suggest that having a female teacher increases reading test scores by 16.1 points for girls ($\beta_2 + \beta_3$) and 6.1 points for boys (β_2), while math test scores increase by 18.1 points for girls and 9.6 points for boys.[11]

A number of further control variables can account for differences in test scores: As for student characteristics, age, schooling history, and family background are significant predictors of educational outcomes. Among class characteristics, significant factors include multi-grade class status, teacher resources, and whether students are permitted to take home textbooks. In addition, many school characteristics are important predictors of student performance. Students, on average, perform better in urban schools, in private schools, and in schools with access to electricity. In line with earlier research for Sub-Saharan Africa (Fehrler et al., 2009), most teacher characteristics play no role in grade 2 student learning outcomes. The only significant teacher variables besides teacher gender are teacher salary and whether the teacher uses the local language instead of French in class.

We can check for the suitability of our hierarchical model by examining the variance structure of our data presented at the bottom of Table 4. In the reduced models of columns (1) and (4) that control for country and gender effects only, it becomes clear that much of the

remaining variance is on the school level (σ_u^2). The LR test confirms that the model performs better than a simple linear model. When adding a broad set of variables that account for teacher and school characteristics in models (2), (3), (5) and (6), the remaining variance of the school-level error component falls, but is still substantial, indicating differences in school productivity that are largely unobservable.[12]

IV.2 Grade 6 students

Results for grade 6 students are presented in Table 5. The sample for these older students is significantly larger than that for younger students examined above. It comprises 31,188 girls and boys in 1,806 schools. In contrast to the sample of young primary school students used in the previous section, 6th graders have been exposed to their particular learning environment for four more years and thus should show rather long-run effects of learning. Columns (1) and (4) again present the reduced specification only controlling for country fixed effects, school random effects, and student and teacher gender. In line with the results from grade 2 students, we see that on average male students perform better in both subjects and that being taught by female teachers increases learning outcomes. Effects are highly statistically significant, yet somewhat lower in magnitudes compared to the younger sample. When adding student, teacher, class, and school control variables in columns (2) and (5), both student and teacher gender effects remain roughly unchanged.

[Table 5 about here]

The same-gender teacher effect is added to the models in columns (3) and (6), and it is again positive and highly statistically significant, as in the younger sample. The coefficients indicate that having a female teacher increases reading test scores by 26.2 points for girls and by 16.6 points for boys, while math test scores increase by 29.9 points for girls and 6.8 points for boys.

Again, numerous significant predictors of student performance have been identified among student, teacher, class and school characteristics. Most of the control variable effects are in line with the findings from Table 4. Some new, additional effects have emerged. New, significant predictors of student achievement now include teacher's absence rate, teacher's general education level, as well as the number of students sharing a textbook. In addition, students perform slightly better if the school has a female principal. In contrast to grade 2 students, grade 6 students have been additionally asked to indicate their involvement in child labor activities. Estimation results show that the more a child is involved in farming, business-related activities, or in other physical labor, the lower it scores on math and reading tests.

IV.3 Students' appreciation of reading and mathematics

Good teachers can help students to develop an intrinsic motivation for a particular subject. Teacher gender might play an important role here since male teachers might be more likely to stick to traditional believes that math is a rather "male" subject. Moreover, if the appreciation of a subject is correlated with student achievement, higher achievement under a female teacher would also increase students' appreciation of the subject. Table 6 explores the determinants of students' appreciation of reading and math. Sixth graders were asked to indicate how much they

agree to the statements ‘I like reading.’ and ‘I like mathematics.’ Students were given four response categories to choose from and we arranged them on a scale from 1 to 4 (4= ‘completely agree’; 3= ‘agree’; 2= ‘disagree’; 1= ‘completely disagree’). These variables are referred to as ‘likeread’ and ‘likemath’.

[Table 6 about here]

The determinants of students’ appreciation of reading and math are presented in Table 6. Appreciation of reading is positively related to family educational background. Literacy of other family members, the extent to which French is spoken at home, and the availability of books at home all increase a student’s affinity for reading. So does also the possibility of taking home reading textbooks and being enrolled in a private school. In contrast, being involved in child labor activities reduces students’ reading appreciation.

In line with the results for reading, math appreciation is also strongly related to family educational background and the possibility to take home math textbooks.

As in earlier regressions, our particular interest lies in gender effects. Findings indicate that girls, compared to their male schoolmates, are less likely to enjoy reading and math when taught by male teachers. However, these gender gaps in subject appreciation reverse when students are taught by a female teacher. This finding is in line with earlier results and adds to the evidence that same-gender effects matter for educational outcomes in Western and Central Africa.

V. Concluding remarks

This article analyzed the relationship between teacher gender, student gender, and student achievement in mathematics and reading in Western and Central Africa, a region lagging behind global trends in educational gender equality. Drawing on one of the largest education assessment programs ever carried out in developing countries, and using a multilevel model to account for clustering within schools, we studied effects of student-teacher gender allocations separately for 2^{nd} and 6^{th} graders. Our findings indicate that being taught by a female teacher boosts academic achievements of all students, but particularly that of girls. The finding that girls benefit more from having a female teacher compared to boys suggests that same-gender effects play an important role in understanding gender gaps in education in Sub-Saharan Africa. In addition, we find that students' subject appreciation rises when taught by a same-gender teacher. Finally, our results suggest that traditional academic gender stereotypes continue to play an important role in the region. We find that teachers' perceptions of the relative performance of girls vs. boys stands in stark contrast to the actual relative performance of these two groups. In particular, boys' math performance is largely overestimated.

In many Sub-Saharan countries, in particular in Western and Central Africa, large gender gaps remain in the access to the teaching profession. In addition, female students continue to lack behind male students in learning achievement. Our results provide direct implications for policy makers to increase gender equality and the quality of primary education. In particular, our findings suggest that hiring more female teachers in the region can contribute to a reduction in educational gender gaps without hurting boys.

[1] Table A1 in the appendix shows the shares of female teachers among all teachers by country and region. The ten Western and Central African countries included in the table are those that form part of the PASEC data used in this study.

[2] A third, less well understood channel is sexual harassment and gender-based violence which has been observed within African primary schools in some studies (Dunne et al., 2006; Devers et al., 2012).

[3] Since only one class per school has been sampled, all students from the same school have the same teacher. In addition, primary school students in our data are taught by only one teacher, thus we need to control for only one teacher's gender.

[4] PASEC collects data only from one class (for each grade 2 and 6) per school. Each class is taught by one teacher.

[5] A detailed description of all variables is provided in Table A2 in the appendix.

[6] Note that one could have also thought about setting up a three-level model using the country as the third level. However, as there are only 10 countries in our dataset, this might lead to inconsistent estimates for the country-level variance component.

[7] Besides its potential effect on $\hat{\beta}_2$, which we expect to be limited, it should be noted that it is much less plausible that non-random assignment could also bias $\hat{\beta}_3$, the 'same-gender teacher' estimate.

[8] In spite of different historical, political and economic backgrounds, the 10 countries have allocated a considerable share of their public expenditure on education to primary education, and also have a similar education system, which follows the French pattern very closely. In addition, all countries except for Burundi share the CFA-Franc as their currency, which is pegged to the Euro (EUR 1 = CFA 655.957).

9 On the first stage, schools were selected according to a systematic procedure. Strata were built from the official country list of schools that have students enrolled at the targeted grades. As stratification variables the following variables were used: regions or districts (varies by country), type of schools, geographical location (urban/rural). In each stratum, schools are sampled using Systematic Probability Proportional to Size (PPS) sampling. Per country, the standard sample size is 180 schools for grade 6 and 90 schools for grade 2. On the second stage, one classroom at the targeted grade was selected in the sampled schools using simple random sampling. On the third stage, 20 students in grade 6 and 10 students in grade 2 were selected in each sampled classroom using simple random

sampling. If a classroom had 20 students or less in grade 6 and 10 students or less in grade 2, all students were selected.

[10] All countries except Burundi used French; in Burundi, the language of the test was Kirundi.

[11] For girls, the effect of having a female teacher is $(\beta_2 + \beta_3)$, while for boys the effect of a female teacher is (β_2). See Table A3 in the appendix for a full classification of gender effects.

[12] Although we are convinced that the multilevel model performs better than an OLS model that accounts for clustering on the school level, we ran the latter as a robustness check since it has been used in some of the earlier literature. OLS estimates are very similar to the ones obtained in our multilevel regressions. Results are not displayed here but can be obtained from the authors upon request.

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Tables and Figures

Table 1: Descriptive statistics by teacher-student gender allocation (*grade 2*)

	Male teacher				Female teacher			
	Male student		Female student		Male student		Female student	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Student achievement								
reading	487.23	96.98	487.19	100.02	513.87	94.20	518.36	97.72
math	493.52	98.32	482.69	102.25	517.75	93.63	513.03	95.54
Student characteristics								
s_age	8.34	1.54	8.25	1.49	7.94	1.26	7.80	1.26
s_preschool	0.19		0.23		0.34		0.36	
s_repeatgrade	0.15		0.14		0.12		0.12	
s_frenchathome	0.47	0.70	0.56	0.75	0.64	0.73	0.68	0.73
s_famliteracy	0.75		0.80		0.84		0.86	
s_booksathome	0.36		0.36		0.46		0.47	
Teacher characteristics								
t_edu	5.77	3.03	5.68	3.13	6.26	3.03	6.15	3.02
t_profdegree	0.72		0.74		0.80		0.79	
t_initialtrain	2.59	1.39	2.69	1.40	3.02	1.24	3.08	1.22
t_jobtrain	0.70		0.72		0.83		0.86	
t_experience	9.09	8.20	9.12	8.06	6.86	6.20	6.72	5.74
t_regular	0.34		0.37		0.26		0.27	
t_netmsalary	4.64	2.71	4.71	2.71	5.35	2.53	5.14	2.51
t_otherjob	0.36		0.34		0.23		0.21	
t_absence	1.66	2.90	1.79	3.00	1.34	2.14	1.35	2.03
t_meetparents	0.92		0.92		0.92		0.93	
t_meetcolleagues	0.93		0.94		0.97		0.97	
t_locallanginclass	2.45	0.85	2.45	0.86	2.35	0.86	2.32	0.88
Class characteristics								
c_rbooktakehome	0.26		0.26		0.34		0.34	
c_mbooktakehome	0.13		0.12		0.18		0.17	
c_manuals_french	0.95		0.96		0.97		0.96	
c_manuals_math	0.91		0.92		0.91		0.91	
c_num	45.96	26.54	46.09	26.19	54.03	30.76	53.00	29.64
c_hours	27.66	6.78	27.95	7.53	27.43	7.88	27.60	7.78
c_multigrade	0.26		0.25		0.11		0.11	
c_bookshare_french	2.97	1.91	2.86	1.85	2.71	1.81	2.65	1.79
c_bookshar_math	3.20	2.19	3.10	2.12	3.31	2.23	3.22	2.19
c_teachresourceindex	48.52	8.51	48.87	8.92	50.82	11.43	51.33	11.80
School characteristics								

s_size	357.08	308.13	379.02	331.46	452.59	343.55	431.85	317.91
s_urban	0.25		0.25		0.47		0.48	
s_type1 (community)	0.05		0.05		0.02		0.02	
s_type2 (public)	0.80		0.81		0.73		0.70	
s_type3 (private)	0.15		0.14		0.25		0.28	
s_femprincipal	0.15		0.18		0.24		0.29	
s_teacherabsence	1.85	0.70	1.85	0.72	1.93	0.75	1.94	0.75
s_electricity	0.15		0.15		0.19		0.19	
s_infraindex	48.09	10.06	48.76	9.76	50.80	10.24	51.76	10.07
Observations (max)	2413		2260		2008		1976	

Notes: Variables for which no s.d. is reported are dummy variables.

Table 2: Descriptive statistics by teacher-student gender allocation (*grade 6*)

	Male teacher				Female teacher			
	Male student		Female student		Male student		Female student	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Student achievement								
reading	488.45	97.07	496.62	98.90	515.06	80.92	520.94	86.34
math	487.83	92.75	486.50	92.42	534.01	92.02	540.02	104.29
Subject appreciation								
likeread	3.20	0.76	3.20	0.77	3.22	0.73	3.26	0.69
likemath	3.08	0.80	3.06	0.81	2.98	0.83	3.00	0.82
Student characteristics								
s_age	12.67	1.65	12.50	1.57	13.38	1.81	13.35	1.94
s_preschool	0.27		0.29		0.29		0.29	
s_repeatgrade	0.56		0.55		0.64		0.63	
s_frenchathome	0.88	0.53	0.89	0.52	0.77	0.57	0.81	0.55
s_famliteracy	0.94		0.95		0.97		0.97	
s_booksathome	1.68	0.78	1.75	0.81	1.61	0.79	1.65	0.81
s_housework	2.00	0.98	2.20	0.93	2.08	0.97	2.14	0.95
s_farmwork	1.54	1.15	1.31	1.17	1.45	1.12	1.33	1.14
s_commercework	0.90	1.07	0.97	1.09	0.86	1.03	0.90	1.06
s_physwork	0.61	0.97	0.45	0.87	0.53	0.92	0.50	0.90
Teacher characteristics								
t_edu	5.82	2.77	5.85	2.77	5.22	3.10	5.31	3.08
t_profdegree	0.86		0.87		0.93		0.93	
t_initialtrain	3.06	1.29	3.09	1.26	3.49	1.25	3.54	1.20
t_jobtrain	0.82		0.85		0.74		0.75	
t_experience	11.89	8.11	12.47	8.16	10.77	7.48	10.85	7.21
t_regular	0.47		0.47		0.64		0.63	
t_netmsalary	5.79	2.90	5.86	2.90	5.48	2.57	5.58	2.71
t_otherjob	0.28		0.27		0.21		0.20	
t_absence	1.50	2.34	1.41	2.22	1.21	1.79	1.28	2.03
t_meetparents	0.97		0.97		0.96		0.95	
t_meetcolleagues	0.97		0.98		0.97		0.98	
t_locallanginclass	1.97	0.66	1.96	0.64	2.23	0.73	2.20	0.72
Class characteristics								
c_rbooktakehome	0.56		0.61		0.62		0.61	
c_mbooktakehome	0.55		0.59		0.54		0.54	
c_manuals_french	0.96		0.97		0.98		0.98	
c_manuals_math	0.96		0.96		0.97		0.97	
c_num	38.34	23.87	39.86	23.45	43.60	22.07	43.64	22.34

c_hours	28.88	7.59	29.16	7.60	32.23	9.97	32.51	9.76
c_multigrade	0.24		0.19		0.06		0.07	
c_bookshare_french	2.59	1.79	2.41	1.70	2.56	1.40	2.50	1.41
c_bookshar_math	2.69	1.96	2.48	1.84	2.77	1.72	2.74	1.76
c_teachresourceindex	50.15	10.51	50.81	10.84	48.88	9.29	48.47	8.20
School characteristics								
s_size	385.17	324.99	396.27	324.46	509.08	328.97	508.67	336.14
s_urban	0.35		0.37		0.31		0.34	
s_type1 (community)	0.04		0.03		0.02		0.01	
s_type2 (public)	0.76		0.76		0.86		0.87	
s_type3 (private)	0.20		0.21		0.12		0.12	
s_femprincipal	0.11		0.11		0.57		0.56	
s_teacherabsence	1.87	0.72	1.86	0.72	2.07	0.76	2.05	0.75
s_electricity	0.21		0.23		0.12		0.14	
s_infraindex	49.42	10.30	50.70	9.96	48.23	9.40	48.84	9.46
Observations (max)	12894		11175		3648		3471	

Notes: Variables for which no s.d. is reported are dummy variables.

Table 3: Teacher gender and perceived vs. actual performance of grade 6 boys vs. girls

	Male teacher				Female teacher			
	Boys perceived better	Girls perceived better	Boys actually better	Girls actually better	Boys perceived better	Girls perceived better	Boys actually better	Girls actually better
Math performance	0.417	0.130	0.647	0.353	0.386	0.161	0.415	0.585
	[1333]	[1333]	[1333]	[1333]	[386]	[386]	[386]	[386]
Reading performance	0.270	0.252	0.567	0.433	0.178	0.300	0.420	0.580
	[1343]	[1343]	[1343]	[1343]	[383]	[383]	[383]	[383]

Notes: Numbers present the share of classes in which a particular gender actually performed better or is perceived by the teacher to perform better. Actual performance is based on test scores comparing girls and boys in the same class. Perceptions are based on teacher's subjective view. “Girls performed better” and “boys performed better” don’t add up to one because the third category “no difference” is not reported. Number of schools in brackets.

Table 4: Student-teacher gender allocation and reading and math performance (*grade 2*)

	(1) reading	(2) reading	(3) reading	(4) math	(5) math	(6) math
Student and teacher gender						
s_female	-3.711***	-3.295**	-7.632***	-12.54***	-11.29***	-14.92***
	(1.244)	(1.423)	(1.887)	(1.443)	(1.642)	(2.176)
t_female	33.22***	11.00**	6.111	30.31***	13.75***	9.640**
	(4.622)	(4.279)	(4.500)	(4.288)	(4.399)	(4.685)
samegender_female			10.02***			8.412**
			(2.867)			(3.310)
Student characteristics						
s_age		5.499***	5.526***		10.83***	10.86***
		(0.736)	(0.735)		(0.845)	(0.845)
s_preschool		7.198***	7.217***		3.705	3.694
		(2.035)	(2.033)		(2.329)	(2.328)
s_repeatgrade		-12.52***	-12.67***		-7.297***	-7.436***
		(2.251)	(2.249)		(2.596)	(2.595)
s_frenchathome		19.76***	19.77***		17.32***	17.34***
		(1.825)	(1.823)		(2.103)	(2.102)
s_famliteracy		10.50***	10.69***		18.21***	18.37***
		(2.212)	(2.211)		(2.540)	(2.539)
s_booksathome		16.51***	16.50***		16.33***	16.33***
		(1.848)	(1.846)		(2.071)	(2.070)
Teacher characteristics						
t_edu		-0.584	-0.570		-0.605	-0.592
		(0.658)	(0.658)		(0.677)	(0.677)
t_profdegree		0.660	0.732		-0.307	-0.286
		(6.073)	(6.071)		(6.287)	(6.284)
t_initialtrain		-0.0804	-0.117		-1.278	-1.290
		(1.875)	(1.874)		(1.943)	(1.942)
t_jobtrain		1.111	1.093		3.958	3.931
		(4.961)	(4.959)		(5.106)	(5.103)
t_experience		-0.241	-0.240		-0.133	-0.133
		(0.287)	(0.287)		(0.295)	(0.295)
t_regular		-6.056	-6.217		-1.555	-1.714
		(5.870)	(5.868)		(6.076)	(6.073)
t_netmsalary		1.602**	1.647**		1.181	1.216
		(0.756)	(0.756)		(0.781)	(0.781)
t_otherjob		-4.520	-4.474		0.0410	0.0950
		(4.396)	(4.395)		(4.515)	(4.513)
t_absence		-0.535	-0.520		-0.667	-0.657
		(0.715)	(0.715)		(0.743)	(0.742)
t_meetparents		8.637	8.419		4.366	4.196
		(7.431)	(7.430)		(7.750)	(7.746)
t_meetcolleagues		14.67	14.56		20.12*	20.03*
		(10.09)	(10.08)		(10.31)	(10.30)
t_locallanginclass		-5.881**	-5.903**		-3.077	-3.106
		(2.760)	(2.759)		(2.810)	(2.808)
Class characteristics						

c_rbooktakehome		17.53***	17.36***			
		(2.550)	(2.548)			
c_mbooktakehome					14.25***	14.13***
					(3.609)	(3.607)
c_manuals_french		-2.646	-2.330			
		(10.88)	(10.88)			
c_manuals_math					8.111	8.224
					(7.630)	(7.626)
c_num		-0.170*	-0.172*		-0.115	-0.118
		(0.0934)	(0.0934)		(0.0974)	(0.0973)
c_hours		0.324	0.312		-0.0404	-0.0493
		(0.306)	(0.305)		(0.314)	(0.313)
c_multigrade		-11.33*	-11.21*		-16.48***	-16.42***
		(5.925)	(5.924)		(6.036)	(6.033)
c_bookshare_french		-1.641	-1.655			
		(1.317)	(1.317)			
c_bookshar_math					-0.647	-0.633
					(1.231)	(1.231)
c_teachingresourceindex		0.923***	0.922***		0.520**	0.520**
		(0.228)	(0.228)		(0.235)	(0.235)
School characteristics						
s_size		-0.0116	-0.0112		-0.0138*	-0.0134*
		(0.00765)	(0.00765)		(0.00806)	(0.00805)
s_urban		25.98***	25.99***		24.32***	24.36***
		(5.052)	(5.051)		(5.235)	(5.232)
s_type1 (community)		9.270	9.067		18.53	18.36
		(12.09)	(12.09)		(12.56)	(12.55)
s_type 2 (public)		Reference	Reference		Reference	Reference
s_type3 (private)		27.77***	27.64***		18.96***	18.84***
		(6.730)	(6.728)		(6.930)	(6.926)
s_femprincipal		8.138	7.935		9.925*	9.729*
		(5.388)	(5.386)		(5.604)	(5.601)
s_teacherabsence		-4.899*	-5.020*		-4.204	-4.312
		(2.682)	(2.681)		(2.764)	(2.763)
s_electricity		17.26***	17.29***		13.01**	12.98**
		(5.913)	(5.912)		(6.096)	(6.093)
s_infraindex		0.407	0.405		0.303	0.303
		(0.264)	(0.264)		(0.274)	(0.274)
Constant	448.3***	310.7***	313.0***	446.5***	284.0***	285.9***
	(7.629)	(27.85)	(27.85)	(7.091)	(27.32)	(27.32)
var_u	4070.4	2027.7	2026.8	3340.8	2012.4	2010.6
var_e	2947.4	2864.4	2859.0	3990.4	3741.8	3736.9
LR test vs. OLS (p-value)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Observations	8,657	6,413	6,413	8,657	6,251	6,251
Number of groups	931	722	722	931	703	703

Notes: Random intercept models. Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1. All models include country fixed effects and school random effects.

Table 5: Student-teacher gender allocation and reading and math performance (*grade 6*)

	(1) reading	(2) reading	(3) reading	(4) math	(5) math	(6) math
Student and teacher gender						
s_female	-2.236***	-2.932***	-5.302***	-6.442***	-5.775***	-11.50***
	(0.688)	(0.778)	(0.895)	(0.667)	(0.777)	(0.891)
t_female	24.83***	21.27***	16.59***	20.92***	18.03***	6.838*
	(4.671)	(3.640)	(3.744)	(4.370)	(3.807)	(3.906)
samegender_female			9.613***			23.07***
			(1.794)			(1.783)
Student characteristics						
s_age		-4.530***	-4.557***		-3.286***	-3.357***
		(0.296)	(0.295)		(0.295)	(0.294)
s_preschool		0.686	0.690		-3.433***	-3.449***
		(1.042)	(1.041)		(1.041)	(1.037)
s_repeatgrade		-22.26***	-22.24***		-18.89***	-18.82***
		(0.897)	(0.897)		(0.898)	(0.894)
s_frenchathome		4.856***	4.764***		4.630***	4.422***
		(0.894)	(0.894)		(0.896)	(0.892)
s_famliteracy		18.64***	18.53***		15.51***	15.24***
		(2.191)	(2.190)		(2.200)	(2.191)
s_booksathome		4.498***	4.505***		2.694***	2.714***
		(0.631)	(0.631)		(0.632)	(0.629)
s_housework		0.792*	0.898*		0.0547	0.311
		(0.463)	(0.463)		(0.463)	(0.462)
s_farmwork		-3.899***	-3.962***		-1.409***	-1.561***
		(0.430)	(0.430)		(0.431)	(0.429)
s_commercework		-2.864***	-2.843***		-3.091***	-3.049***
		(0.406)	(0.406)		(0.406)	(0.404)
s_physwork		-4.923***	-5.003***		-3.105***	-3.301***
		(0.504)	(0.504)		(0.505)	(0.503)
Teacher characteristics						
t_edu		1.390***	1.387***		0.796*	0.793*
		(0.429)	(0.430)		(0.447)	(0.447)
t_profdegree		-3.328	-3.298		-1.023	-0.954
		(4.584)	(4.586)		(4.781)	(4.784)
t_initialtrain		0.669	0.652		-0.0580	-0.0947
		(1.086)	(1.087)		(1.129)	(1.129)
t_jobtrain		1.532	1.602		3.546	3.688
		(3.130)	(3.131)		(3.263)	(3.265)
t_experience		0.0746	0.0776		0.0275	0.0348
		(0.171)	(0.171)		(0.179)	(0.180)
t_regular		1.973	1.897		2.841	2.686
		(3.355)	(3.356)		(3.506)	(3.508)
t_netmsalary		0.778*	0.779*		0.845*	0.849*
		(0.431)	(0.431)		(0.449)	(0.450)
t_otherjob		0.554	0.573		0.616	0.658
		(2.847)	(2.848)		(2.976)	(2.978)
t_absence		-1.880***	-1.886***		-1.625***	-1.633***

		(0.559)	(0.559)		(0.579)	(0.579)
t_meetparents		9.451	9.436		7.264	7.308
		(6.929)	(6.932)		(7.384)	(7.388)
t_meetcolleagues		0.0662	0.0548		-4.391	-4.414
		(8.137)	(8.141)		(8.482)	(8.487)
t_locallanginclass		-4.114**	-4.143**		-1.066	-1.114
		(1.943)	(1.944)		(2.020)	(2.021)
Class characteristics						
c_rbooktakehome		9.045***	9.047***			
		(1.179)	(1.179)			
c_mbooktakehome					10.32***	10.32***
					(1.151)	(1.147)
c_manuals_french		8.366	8.387			
		(6.608)	(6.611)			
c_manuals_math					20.32***	20.10***
					(6.761)	(6.764)
c_num		-0.172**	-0.171**		-0.0987	-0.0962
		(0.0741)	(0.0742)		(0.0773)	(0.0773)
c_hours		0.167	0.167		0.260	0.258
		(0.154)	(0.154)		(0.162)	(0.162)
c_multigrade		-10.47***	-10.60***		-12.17***	-12.53***
		(3.537)	(3.539)		(3.681)	(3.683)
c_bookshare_french		-4.661***	-4.655***			
		(0.869)	(0.869)			
c_bookshar_math					-3.829***	-3.833***
					(0.833)	(0.833)
c_teachingresourceindex		0.849***	0.853***		0.824***	0.834***
		(0.149)	(0.149)		(0.155)	(0.156)
School characteristics						
s_size		0.00700	0.00692		0.00693	0.00679
		(0.00488)	(0.00489)		(0.00512)	(0.00512)
s_urban		31.44***	31.39***		17.35***	17.26***
		(3.200)	(3.202)		(3.328)	(3.330)
s_type1 (community)		19.34**	19.38**		11.84	11.88
		(8.274)	(8.277)		(8.704)	(8.708)
s_type 2 (public)						
s_type3 (private)		26.71***	26.70***		28.87***	28.84***
		(4.561)	(4.563)		(4.761)	(4.764)
s_femprincipal		7.672**	7.610**		6.906*	6.721*
		(3.500)	(3.501)		(3.678)	(3.680)
s_teacherabsence		-0.537	-0.520		-1.123	-1.094
		(1.649)	(1.650)		(1.727)	(1.728)
s_electricity		17.91***	17.86***		17.43***	17.27***
		(3.602)	(3.604)		(3.745)	(3.747)
s_infraindex		0.661***	0.660***		0.709***	0.707***
		(0.166)	(0.166)		(0.171)	(0.171)
Constant	502.9***	433.1***	434.6***	481.3***	387.5***	391.3***
	(5.273)	(19.17)	(19.18)	(4.933)	(19.68)	(19.69)
var_u	4313.9	1769.0	1770.7	3761.4	1938.6	1943.0

var_e	3345.5	3058.1	3053.7	3150.6	3029.4	3005.2
LR test vs. OLS (p-value)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Observations	31,188	22,904	22,904	31,188	22,758	22,758
Number of groups	1,806	1,514	1,514	1,806	1,511	1,511

Notes: Random intercept models. Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1. All models include country fixed effects and school random effects.

Table 6: Students' appreciation of reading and math (grade 6)

	(1) likeread	(2) likemath
s_female	-0.0312***	-0.0451***
	(0.0107)	(0.0116)
t_female	-0.00103	-0.0312
	(0.0294)	(0.0320)
samegender_female	0.0751***	0.0948***
	(0.0214)	(0.0232)
Student characteristics		
s_age	-0.0105***	-0.00700*
	(0.00346)	(0.00376)
s_preschool	0.00355	-0.0153
	(0.0123)	(0.0133)
s_repeatgrade	-0.0868***	-0.0264**
	(0.0106)	(0.0115)
s_frenchathome	0.0558***	0.0447***
	(0.0104)	(0.0113)
s_famliteracy	0.142***	0.103***
	(0.0256)	(0.0278)
s_booksathome	0.0303***	0.0149*
	(0.00732)	(0.00795)
s_housework	0.0336***	0.0140**
	(0.00544)	(0.00592)
s_farmwork	-0.00906*	0.00245
	(0.00500)	(0.00545)
s_commercework	-0.0125***	0.00144
	(0.00477)	(0.00519)
s_physwork	-0.0115**	0.000722
	(0.00585)	(0.00637)
Teacher characteristics		
t_edu	0.00368	-0.00213
	(0.00325)	(0.00352)
t_profdegree	-0.0354	-0.0544
	(0.0347)	(0.0376)
t_initialtrain	0.00859	0.0136
	(0.00818)	(0.00884)
t_jobtrain	0.0166	0.0270
	(0.0236)	(0.0256)
t_experience	0.00103	0.000311
	(0.00129)	(0.00141)
t_regular	-0.00871	-0.0272
	(0.0254)	(0.0276)
t_netmsalary	-0.00441	-0.00444
	(0.00327)	(0.00356)
t_otherjob	0.0152	-0.00290
	(0.0215)	(0.0235)
t_absence	0.00323	-0.00119
	(0.00422)	(0.00455)

t_meetparents	-0.00557	-0.0222
	(0.0523)	(0.0581)
t_meetcolleagues	0.0554	0.0352
	(0.0617)	(0.0669)
t_locallanginclass	-0.0339**	0.00393
	(0.0147)	(0.0159)
Class characteristics		
c_rbooktakehome	0.0738***	
	(0.0132)	
c_mbooktakehome		0.0686***
		(0.0142)
c_manuals_french	-0.0128	
	(0.0504)	
c_manuals_math		0.0800
		(0.0538)
c_num	0.000770	0.00135**
	(0.000559)	(0.000607)
c_hours	-0.000811	-0.00185
	(0.00116)	(0.00127)
c_multigrade	-0.00133	0.0586**
	(0.0272)	(0.0295)
c_bookshare_french	0.00452	
	(0.00664)	
c_bookshar_math		0.00351
		(0.00663)
c_teachingresourceindex	0.00138	0.000200
	(0.00112)	(0.00122)
School characteristics		
s_size	-1.29e-05	2.80e-05
	(3.66e-05)	(3.99e-05)
s_urban	0.0319	-0.0190
	(0.0242)	(0.0262)
s_type1 (community)	0.0116	-0.0159
	(0.0633)	(0.0692)
s_type 2 (public)		
s_type3 (private)	0.0873**	0.0145
	(0.0345)	(0.0375)
s_femprincipal	0.0138	-0.0277
	(0.0263)	(0.0287)
s_teacherabsence	-0.0264**	-0.00668
	(0.0125)	(0.0136)
s_electricity	0.0416	0.0556*
	(0.0270)	(0.0292)
s_infraindex	-0.000107	-0.000383
	(0.00126)	(0.00135)
Constant	3.029***	2.895***
	(0.151)	(0.162)
var_u	0.082	0.096
var_e	0.437	0.513

LR test vs. OLS (p-value)	(0.000)	(0.000)
Observations	22,726	22,583
Number of groups	1,514	1,511

Notes: Random intercept models. Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1. All models include country fixed effects and school random effects.

Appendix

Table A1: Share of female teachers in primary schools over time (in percent)

	1975	*1995*	*2015*
Benin	27.5	24.7	23.9
Burkina Faso	17.4	24.5	44.6
Burundi	42.2	46.8	51.6
Cameroon	12.7	31.7	54.2
Chad	5.3	7.8	15.4
Congo	15.5	33.4	53.5
Cote d'Ivoire	12.1	18.4	27.8
Niger	32.3	33.4	49.7
Senegal	20.6	25.8	32.4
Togo	20.0	16.0	15.8
PASEC country avg	*20.5*	*26.2*	*36.9*
Developed countries	78.9	82.1	84.5
Developing countries	42.6	51.9	59.3
Sub-Saharan Africa	37.5	43.5	44.9

Source: UNESCO Institute for Statistics, 2017.

Table A2: Variable Description and Basic Summary Statistics

	Variable description	Grade 2		Grade 6	
		Mean	SD	Mean	SD
Student achievement					
reading	Student reading test score	500.24	98.58	498.14	95.51
math	Student math test score	500.53	98.95	498.64	96.23
Subject appreciation					
likeread	Agreement to the statement "I like reading"; (4= 'completely agree'; 3= 'agree'; 2= 'disagree'; 1= 'completely disagree')			3.21	0.75
likemath	Agreement to the statement "I like math"; (4= 'completely agree'; 3= 'agree'; 2= 'disagree'; 1= 'completely disagree')			3.06	0.81
Gender variables					
s_female	Student gender (1=female; 0=male)	0.49		0.47	
t_female	Teacher gender (1=female; 0=male)	0.46		0.23	
samegender_female	s_female*t_female	0.23		0.11	
Student characteristics					
s_age	Age in years	8.10	1.42	12.77	1.71
s_preschool	Attended pre-school (Y=1; N=0)	0.27		0.28	0.45
s_repeatgrade	Repeats current grade (Y=1; N=0)	0.14		0.58	0.49
s_frenchathome	Degree to which French is spoken at home (2= 'speaks always French'; 1= 'partly French and partly another language'; 0= 'never speaks French')	0.58	0.73	0.87	0.53
s_famliteracy	Has a literate family member (Y=1; N=0)	0.81		0.95	
s_booksathome	Grade 2: Has books at home (Y=1; N=0). Grade 6: Number of books at home (No books=1; enough books to fill a shelf=2; enough books to fill two shelves=3; enough books to fill a library=4)	0.41		1.69	0.80
s_housework	Does housework (farmwork, commercial work, physical work) when not in school (0= 'never'; 1= 'sometimes'; 2= 'often'; 3= 'always')			2.10	0.96
s_farmwork				1.42	1.16
s_commercework				0.92	1.07
s_physwork				0.53	0.93
Teacher characteristics					
t_edu	Years of general schooling received by teacher (1 to 13)	5.95	3.06	5.70	2.86
t_profdegree	Teacher has a professional degree (Y=1; N=0)	0.76		0.88	
t_initialtrain	Initial vocational training (no training=1, less than 6 months=2, 1yr=3, 2 yrs=4, 3 yrs=5, over 3 yrs=6)	2.83	1.34	3.18	1.28
t_jobtrain	Received on the job training during the past 2 years (Y=1; N=0)	0.77		0.81	
t_experience	Teaching experience in years	8.04	7.32	11.86	7.99
t_regular	Regular employee/ teacher (Y=1; N=0)	0.31		0.50	
t_netmsalary	Teacher net salary (CFA franc per month incl. bonuses and allowances): 1= 'Below 14,000'; 2= '15,000~29,000'; 3= '30,000~59,000'; 4= '60,000~89,000'; 5= '90,000~119,000'; 6= '120,000~149,000'; 7= '150,000~199,000'; 8= '200,000~249,000'; 9= '250,000~299,000'; 10= '300,000~349,000'; 11= '350,000~399,000'; 12= '400,000~499,000'; 13= 'more than 500,000'	4.94	2.64	5.76	2.84
t_otherjob	Teacher has another job (Y=1; N=0)	0.29		0.26	
t_absence	Number of days absent during the past 4 weeks	1.55	2.60	1.41	2.20
t_meetparents	Teacher met with parents at least once during the	0.92		0.97	

	past year				
t_meetcolleagues	Teacher participated in pedagogical meetings with colleagues at least once during the past year	0.95		0.98	
t_locallanginclass	Degree to which teacher uses majority of students' mother tongue for instruction (1= 'never'; 2= 'occasionally'; 3= 'often'; 4= 'almost always')	2.40	0.86	2.02	0.68
Class characteristics					
c_rbooktakehome	Student allowed to take reading textbook home (Y=1; N=0)	0.29		0.59	
c_mbooktakehome	Student allowed to take math textbook home (Y=1; N=0)	0.15		0.56	
c_manuals_french	Teacher's manual for French available (Y=1; N=0)	0.96		0.97	
c_manuals_math	Teacher's manual for math available (Y=1; N=0)	0.91		0.96	
c_num	Total number of students in class	49.48	28.45	40.07	23.43
c_hours	Number of hours of actual classes per week	27.67	7.47	29.75	8.28
c_multigrade	A multi-grade class: several levels in one class (Y=1; N=0)	0.19		0.18	
c_bookshare_french	The extent to which students have to share French and math textbooks in class (one per student=1; one per 2 students=2; one per 3 students=3; one for 4 students=4; one for more than 4 students=5; no textbook=6)	2.81	1.85	2.51	1.68
c_bookshar_math		3.20	2.18	2.63	1.87
c_teachresourceindex	Index of school teaching resources as provided by PASEC.	49.79	10.23	50.05	10.29
School characteristics					
s_size	Total number of students in school	401.68	326.98	417.14	330.28
s_urban	School is located in urban area (Y=1; N=0)	0.35		0.35	
s_type1 (community)	School is communitarian or a local initiative (Y=1; N=0)	0.04		0.03	
s_type2 (public)	School is public (Y=1; N=0)	0.76		0.78	
s_type3 (private)	School is private (Y=1; N=0)	0.20		0.19	
s_femprincipal	School has a female principal (Y=1; N=0)	0.21		0.22	
s_teacherabsence	Average teacher absences according to school register (1= 'rare (1-2 days per year)'; 2= 'occasional (less than a day per month)'; 3= 'frequent (1-3 days per month)'; 4= 'very frequent (more than 3 days per month)')	1.89	0.73	1.91	0.74
s_electricity	School has access to electricity (Y=1; N=0)	0.17		0.20	
s_infraindex	School infrastructure index as provided by PASEC: availability of lantrines, toilet, source of drinking water, medical kit, teacher room, playground, etc.	49.74	10.13	49.67	10.02
Countries					
BN	Benin (Y=1; N=0)	0.08		0.10	
BF	Burkina Faso (Y=1; N=0)	0.11		0.11	
BR	Burundi (Y=1; N=0)	0.10		0.11	
CM	Cameroon (Y=1; N=0)	0.12		0.12	
CG	Congo (Y=1; N=0)	0.10		0.09	
CI	Côte d'Ivoire (Y=1; N=0)	0.10		0.10	
NI	Niger (Y=1; N=0)	0.09		0.10	
SN	Senegal (Y=1; N=0)	0.09		0.09	
CH	Tchad (Y=1; N=0)	0.09		0.08	
TG	Togo (Y=1; N=0)	0.10		0.10	
Observations (max)		8682		31213	

Notes: Variables for which no s.d. is reported are dummy variables.

Table A3: Test scores by student and teacher gender

	Girls	Boys	Δ
Female teacher	Y_1^1	Y_0^1	$\Delta_1 = Y_1^1 - Y_0^1$ $(\beta_1 + \beta_3)$
Male teacher	Y_1^0	Y_0^0	$\Delta_2 = Y_1^0 - Y_0^0$ (β_1)
Δ	$\Delta_3 = Y_1^1 - Y_1^0$ $(\beta_2 + \beta_3)$	$\Delta_4 = Y_0^1 - Y_0^0$ (β_2)	