**Teaching Practices and Cognitive Skills in Sub-Saharan Africa**

By

Cécile Nadine NGAMBOE, PhD in Economics ([[1]](#footnote-1))

Email address: cecilencn@outlook.com

Affiliation(s): Catholic University of Central

Africa

Department of Social Sciences and Management

P.O Box: 11628, Nkolbisson,Yaoundé, Cameroon

***Abstract:***

*Recent studies on the relationship between educational resources and student achievement suggest a shift from merely providing access to education towards ensuring high-quality education that emphasizes learning outcomes in Sub-Saharan African countries. In this new paradigm, both teachers’ subject content knowledge and pedagogical skills are crucial in influencing student performance. However, there is limited literature in economics exploring how different teaching practices—traditional versus modern—impact cognitive skills in students. By analyzing the 2014 PASEC data set, which includes test scores measuring various cognitive skill dimensions across ten countries, we will demonstrate that teaching practices significantly affect student achievement in Sub-Saharan Africa. This study focuses on instructional methods and classroom environments to identify effective practices that enhance students’ cognitive abilities.*

Keywords: *Teaching practices, cognitive skills, skills development, human capital, educational challenges, instructional approaches, regional educational policy, educational challenges, teacher training, student engagement*

1. **Introduction**

Primary education in sub-Saharan Africa is experiencing a learning crisis that significantly impacts cognitive development and skill acquisition among students (Bold et al., 2019; Psacharopoulos et al., 2020a, 2020b; Nestour et al., 2021). This low level of foundational learning, characterized by inadequate literacy and numeracy skills, can lead to severely diminished future earning potential for individuals and hinder overall economic progress (World Bank, 2018a).

 Individuals with weak foundational skills often struggle to find employment, earn competitive wages, and advance in their careers. On a national level, this results in a less skilled workforce, lower economic growth, and decreased overall societal welfare (Azevedo et al., 2021; Evans and Acosta, 2021).

Recent developments in the relationship between educational resources and student achievement highlight the need to shift from simply providing access to education to promoting effective quality education focused on learning outcomes in Sub-Saharan African countries (Pritchett, 2024). In this new paradigm, teachers’ subject content knowledge and pedagogical skills are crucial for explaining student achievement (Bold, 2017; Bientebeck, 2023). Nonetheless, there is limited literature in economics exploring how different teaching practices impact students’ cognitive skills (Bietenbeck, 2014; Schwerdt and Wuppermann, 2009; Cordero and Gil-Izquierdo, 2018; Iyamuremye et al., 2021).

Numerous studies have emphasized the importance of teaching practices on student outcomes in developed countries; however, there is limited research specifically targeting Sub-Saharan Africa (Mosimege and Winnaar, 2021; Iyamuremye et al., 2021). While Mosimege and Winnaar (2021) conducted a comprehensive review examining the impact of various teaching methodologies on student performance in mathematics, Iyamuremye et al. (2021) found that problem-solving with direct teacher guidance and teacher-teacher interactions are effective instructional practices that significantly enhance students’ performances in mathematics.

This paper contributes to the understanding of how teaching practices impact cognitive skills in the diverse educational landscapes of Sub-Saharan Africa. It specifically examines how differences in teaching practices influence cognitive skill development among various socio-economic and gender groups.

Utilizing the 2014 PASEC data set, which includes test scores that measure performance across different cognitive skill dimensions in ten countries, this study aims to identify effective instructional methods—such as Competence-Based Approaches, Situation-Adaptive Approaches, Teaching by Objectives, and large group-centered teaching—and classroom environments that enhance students’ cognitive abilities.

A common drawback in research on teaching practices is the potential for non-random assignment of students to teachers or schools, which can distort measures of teacher effectiveness due to selection bias (Kane et al., 2011; Bientenbeck, 2014). To mitigate this bias, some studies have employed student fixed effects models or a within-student between-subject approach (Bietenbeck, 2014; Dee, 2007; Schwerdt and Wuppermann, 2011).

To address the issue of selection bias and obtain consistent estimates, various studies have used different types of student fixed effects models to leverage variations across subjects (e.g., Aslam and Kingdon, 2007; Dee, 2007; Schwerdt and Wuppermann, 2011; Bietenbeck, 2014). However, these models assume that unobserved teaching characteristics are uncorrelated with both the teaching practices and the error terms. Therefore, studies focused solely on identifying “teacher quality” may not need to worry about this source of endogeneity (Aslam and Kingdon, 2007; Klareven, 2011).

In contrast, we must address the endogeneity issue, as our analysis incorporates specific teaching practices and may also consider teachers’ characteristics. Some studies tackle this endogeneity by including a range of teacher and classroom characteristics (Bietenbeck, 2013, 2014, 2022), while others use the approach proposed by Altonji, Elder, and Taber (2005). In this paper, we address endogeneity using instrumental variables or two-stage least squares methods, having first conducted necessary tests.

1. **Teaching practices and Cognitive skills: A literature review**

Studies on teaching practices in the United States began after the 1983 report *“A Nation at Risk”* which highlighted flaws in the education system as a key factor in the country’s dwindling competitiveness compared to other nations. This report called for extensive reforms in the national education system, emphasizing the need to improve the quality of instructional practices. In response, the *National Council of Teachers of Mathematics* released *the Curriculum and Evaluation Standards* in 1989, which outlined the mathematics skills students should master at different educational levels. This framework placed a strong emphasis on developing reasoning skills over merely acquiring factual knowledge.

 The shift aimed to align educational practices with the demands of modern labor markets, where reasoning skills are increasingly valued. The central idea of this reform was to enhance mathematical literacy by transforming how mathematics is taught in schools and how students learn. *The Curriculum and Evaluation Standards* received considerable positive attention and led to the creation of similar standards for other subjects, further emphasizing the importance of reasoning skills.

However, the implementation of these recommendations faced criticism. Despite the criticisms, several studies in the mid to late 1990s evaluated the role of these new teaching practices in enhancing learners’ cognitive skills. Researchers compared traditional approaches, which emphasized rote memorization and routine problem-solving, with new methods that focused on student interactions and group work. These studies aimed to determine which approach had a more significant influence on student outcomes and cognitive skills (Aslam and Kingdon, 2008; Klareven, 2011; Lavy, 2016; Cordero and Gil-Izquiedo, 2018). Additionally, some research explored whether the new teaching practices initiated by the reform would lead to long-lasting changes in classroom dynamics (Smith et al., 2000, 2002).

The early studies examine the link between teaching practices and student achievement or cognitive skills. However, many of these studies do not focus on specific teaching practices. Instead, they often start by investigating the determinants of teacher quality. For example, Murnane and Phillips (1981) found that in primary education, teacher behavior variables—such as explaining vocabulary and the percentage of time a teacher uses subgroup discussions, demonstrations, and individualized work—explain a larger proportion of variance in test scores than teacher characteristics alone. While a model incorporating both characteristics and behavioral measures best fits the data, this suggests that other variables, termed teacher behavior variables, play a significant role in explaining test score variance. This conclusion was confirmed in secondary education by Brewer and Goldhaber (1997).

In comparison to the earlier study, Brewer and Goldhaber (1997) included more variables and evaluated the impact of both observable and unobservable schooling characteristics on student outcomes. Through various model specifications, the authors assessed the effect of modern teaching practices on student results. Their findings indicated that a model incorporating teacher behavior variables provided a marginally better explanation of test scores than a model based solely on characteristics. But, combining both sets of variables yielded the best overall fit for the data, suggesting that modern teaching practices positively influence student outcomes.

 Additionally, other categories of teaching practices have been shown to positively impact student achievement. Smith et al. (2001) utilized Hierarchical Linear Modeling to analyze the relationship between different instructional methods—review teaching practices, didactic teaching practices, and interactive teaching practices—and student learning. The authors found that, on average, high levels of interactive instruction contributed an additional five percent to the average one-year achievement gains in reading and mathematics for Chicago students. In contrast, high levels of didactic instruction reduced students' average achievement in both subjects by four percent, and extensive review further diminished gains by another four percent. In other words, interactive instruction had a positive effect on one-year gains in achievement in both reading and mathematics, while didactic instruction and review practices had negative impacts.

However, a long-term study of teaching practices that compared traditional methods (e.g., lecturing) to modern techniques (e.g., group work) between 1993 and 2000 found no significant change in teachers' reported usage of these practices in mathematics over two waves. In science, however, there was a slight reduction in the use of lecturing, while no significant change was observed in the frequency of group work (Smith et al., 2002).

According to Bietenbeck (2014), the relatively short duration of the study may explain the finding, as it might not have been long enough to capture changes in teaching practices. It often takes several years to update textbooks, curricula, and teacher training to align with National Teaching Standards. Therefore, more evidence is needed regarding teaching practices. Subsequent studies on the relationship between teaching methods and cognitive test scores have provided new insights into how these factors interact (Cohen and Hill, 2000; Shacter and Thum, 2004; Matsumura et al., 2006; Wenglinsky, 2006).

In fact, classrooms practices foster two types of skills: higher-order thinking skills and lower-order thinking skills. Because modern teaching practices emphasize hands-on activities that focus on conveying an understanding of concepts and applying that understanding to various problems, students who frequently engage in hands-on learning outperform those who do not. Furthermore, students exposed to higher-order thinking skills tend to achieve better results, while those participating in ongoing assessment activities often perform worse (Welingsky, 2000). Therefore, modern teaching practices are more important than traditional ones for enhancing student performance (Welingsky, 2000, 2002).

In addition to improve student outcomes, modern teaching practices provides teachers with opportunities to deepen their understanding of the curriculum and effectively connect curriculum and assessment. Therefore, simplistic guidelines for teaching are unlikely to be effective unless they consider a combination of curriculum and instructional practices that enhance students' cognitive skills (Cohen and Hill, 2000; McCaffrey et al., 2001).

 Indeed, McCaffrey et al. (2001) indicate that reform-oriented teaching practices positively affect student achievement compared to traditional approaches. However, Newman et al. (2001) emphasize that it is not the specific strategy itself that matters but rather the intellectual demands embedded in classroom tasks. Their study revealed that organizing instruction around challenging, authentic intellectual work leads to students producing more complex work and achieving greater improvements in reading, mathematics, and writing. The authors contend that student success requires not only basic knowledge but also the ability to engage in more complex intellectual activities. The key takeaway is that the intellectual demands of classroom tasks — rather than the mere application of specific teaching strategies or techniques — significantly influence student engagement and learning outcomes.

Some studies indicate that enhancing teacher practices necessitates a focus on the teacher performance system, which boosts teachers’ effectiveness and positively affects students’ cognitive performance (Matsumura et al., 2002, 2006; Shacter and Thum, 2004; Kannapel et al., 2005; Jacob and Lefgren, 2005).

Research on the development of teaching standards and performance rubrics shows that high performance in these areas leads to significant gains in student achievement in reading, language, and mathematics (Shacter and Thum, 2004; Matsumura et al., 2006). These findings validate the use of teaching standards and performance rubrics, suggesting that schools and districts should adopt performance-based measures as the foundation for teacher incentive and compensation systems. Additionally, other measures of teacher quality, such as subjective evaluations by principals, were found to predict future student achievement more effectively than teacher experience, education, or salary (Jacob and Lefgren, 2005).

Also, Kannapel et al. (2005) explored why different groups of students perform differently by examining characteristics and practices that distinguish high-performing, high-poverty schools with small achievement gaps from other similar high-poverty schools that do not perform as well. Their results identified several common practices contributing to improved student achievement, including high expectations, strong relationships, academic and instructional focus, student assessments, effective leadership and decision-making, faculty work ethic, and morale. Their research highlights successful strategies for teacher recruitment, hiring, and assignment as effective means to enhance student performance in high-poverty areas.

The literature on teaching practices also emphasizes computerized instruction, highlighting its effects on student outcomes, grading practices, and assignments. The studies on computerized instruction reveals that instructional computer program improves student’s language/reading skills and mathematics skills (Bonnesronning, 2004; Rouse and Krueger, 2004; Rouse et al., 2004; Banerjee et al., 2007; Barrow et al, 2009). According to Barrow et al (2009) a computerized assisted-instruction in pre-algebra and algebra finds an increase of at least 0.17 standard deviations on average, with significant benefits for students in larger classes. Students using CAI were about 27% of a school year ahead of their peers after one year. This suggests that CAI can effectively enhance mathematics achievement at a lower cost compared to traditional methods.

Also a study of Banerjee et al. (2007) indicated a substantial substantial improvements in test scores—0.14 standard deviations in the first year and 0.28 in the second year—at a minimal cost per child. Those directly involved in the program improved by at least 0.6 standard deviations in the second year. However, while an instructional computer program improved language and reading skills, these gains did not translate into broader measures of language acquisition (Rouse at al, 2004).

There is a significant connection between teaching grading practices and student achievement. A study by Bonnesronning (2004) revealed that teachers influence achievement notably through grading, which can manipulate student effort, especially when perceived achievement impacts higher education admissions. Likewise, Matsumura et al. (2002) found that classroom assignment ratings were reliable indicators of assignment quality.

 Early studies on teaching practices suggested that modern teaching methods are more effective than traditional ones, as they can promote higher-order thinking skills. However, these studies often fail to provide a comprehensive understanding of teaching effectiveness, overlooking crucial factors such as the specific context, a teacher’s individual beliefs and experiences, and the complex interactions between teaching strategies and student learning outcomes or cognitive skills. Additionally, they did not account for the diverse needs of learners or the importance of creating inclusive classrooms that cater to different learning styles and abilities. Students in the same classrooms often have varying levels of ability, which necessitates different teaching approaches from educators. Furthermore, teaching practices may vary according to school policies or the educational policies of different countries.

Recent trends in teaching practices build on earlier studies by exploring the impact of these practices on students’ learning and cognitive skills in relation to the context of the country, schools, and the often unseen abilities of teachers.

 Investigations into the complex nature of teaching have revealed interesting insights into the relationship between teaching practices and the characteristics of teachers that most significantly affect student achievement. Employing a within-student, between-subject approach, or fixed effects model, research indicates that lesson planning, engaging students with questions, and quizzing on prior material substantially benefit student learning. Additionally, a comparative analysis of two types of schools suggested that better public schools tend to hire more effective teachers, while high-quality private schools employ teachers who promote interactive teaching methodologies and pupil testing, often retaining competent teachers through contract renewals (Aslam and Kingdon, 2008).

Despite these findings, many countries have struggled to achieve even basic levels of literacy. For instance, England adopted a policy known as the “literacy hour” through the *National Literacy Strategy* to improve students’ literacy standards. Machin and McNally (2008) assessed the impact of the literacy hour in English primary schools on student attainment using a difference-in-difference approach. Their results indicated that schools participating in the *National Literacy Project* saw greater improvements in reading and English Key Stage 2 scores from 1996 to 1998. The positive effects of the literacy hour persisted until age 16, with boys benefiting more than girls at age 11. In essence, the advantages of the literacy hour outweighed its associated costs, underscoring the importance of both the content taught and the organization of that content for enhancing student achievement.

The literacy hour policy has primarily focused on teachers, but little attention has been given to the policy mechanisms that could improve teacher quality and ensure the equitable distribution of high-quality educators in schools and classrooms. Clotfelter (2010) studied the relationship between teacher credentials and student achievement at the high school level in North Carolina. The availability of test scores in various subjects for each student allows for the estimation of a model that includes student fixed effects, which helps minimize bias related to the non-random distribution of teachers and students across classrooms within schools. The findings offer compelling evidence that teacher credentials—such as years of experience, certification, test scores, and licensing—systematically influence student achievement, with significant implications for policy. This study also highlights the uneven distribution of teacher qualifications among students of different races and socioeconomic statuses, contributing to existing achievement gaps.

 Additionally, the instructional practices of teachers and the time they allocate for instruction significantly impact student cognitive performance (Kane et al., 2011; Klareven, 2011) ([[2]](#footnote-2)). Klareven (2011) explored whether the amount of time teachers spend using a lecturing style affects the cognitive performance of Dutch students. This study examined the connection between lecture-style teaching and student achievement. Utilizing a within-student, between-subject approach, the results revealed no significant relationship between traditional lecturing and student performance. Therefore, the findings do not support the idea that traditional lecturing is obsolete or that a more personalized teaching style would necessarily yield better cognitive outcomes for students.

 Nevertheless, both traditional and modern teaching practices play a crucial role in fostering student achievement, as they promote different cognitive skills (Bietenbeck, 2014; Lavy, 2016). According to Bietenbeck (2014), traditional teaching practices enhance students' knowledge of basic facts and procedures, which have historically been emphasized in education. In contrast, modern teaching practices promote reasoning skills, which the National Teaching Standards recognize as increasingly important in today’s labor market ([[3]](#footnote-3)).

Recent trends indicate that studies generally do not directly compare traditional teaching practices with modern ones. Instead, the research supports the notion that both types of teaching practices are important for developing students' cognitive skills, as they each promote different cognitive skills.

In developing countries, studies on teaching practices are scarce, and few studies have attempted to study the impact of teaching practices on student achievement (Mosimege and Winnaar, 2021; Iyamuremye et al., 2021). Compared to studying in developed countries that emphasize teaching practices such as modern or traditional teaching practices, in developing countries, teaching practices refer to instructional practices (teacher-teacher interaction, teacher-learner interaction, teacher explanation of the content, problem solving with direct teacher guidance, and problem solving without direct teacher guidance).

 Few studies have attempted to examine the relationship between teaching practices and cognitive skills. Studies conducted in the subsaharan African context concluded that the quality of teaching and the quality of teacher-student interactions profoundly impact student outcomes (Carnoy et al, 2015; Arends et al., 2017, Iyamuremye, 2021).

In Botswana, the subject being taught, teacher training, and the use of textbooks significantly influence various teaching behaviors. In general, Teacher behavior in Botswana classrooms is simplistic, features few instructional tools, and is predominantly teacher-centered. Most communication occurs between the teacher and the entire class, with instructional routines relying heavily on didactic teaching. These pedagogical routines demonstrate consistency over time. Also, the modest variation observed among Botswana teachers is notably explained by external organizational factors, particularly curricular structures affected by policy actions, especially within centralized systems (Fuller et al., 1994). However, the study being done in Botswana did not account for the link between didactic teaching skills and students' outcomes. This gap has been overcome by later studies.

Ngware et al. (2014), with the use of mixed methods, found that teaching style plays a crucial role in explaining differences in academic performance among students in primary schools in Kenya. Carnoy et al. (2015) effectively employed a production function model to estimate sixth-grade mathematics learning in three key African countries: Botswana, Kenya, and South Africa. Their analysis demonstrates that teaching quality directly influences student achievement. According to the authors’ findings, higher levels of teacher mathematics knowledge contribute to better mathematics teaching only in South African schools. Also, teachers with more mathematics knowledge are more likely to provide more mathematics coverage in all three countries, but experienced teachers may or may not provide more mathematics coverage. The relation between teacher test score and both the quality of teaching and exposure to mathematics in a classroom is strongest in South Africa. This is important, since it suggests that improvement in teacher mathematics knowledge in South Africa could have a bigger impact on teaching quality and exposure in mathematics in a classroom than in Botswana and Kenya, where teachers scored higher on the teacher test.

Some studies also looked at classroom practices in South African schools (Hoadly, 2012; Arends et al, 2017). While Hoadley's (2012) article reviews classroom-based studies to discern the existing knowledge base surrounding teaching and learning in South African primary schools, Arends et al. (2017), through a hierarchical linear model that considered both teacher and student levels, rigorously examined the correlation between student achievement and specific teacher classroom practices. The results revealed that practices such as Teacher Clarity, Classroom Discussion, Feedback, Formative Assessment, Problem Solving, Metacognitive Strategies, and Collaboration have positively and significantly affected students’ mathematics performance.

Also, studies on the impact of teacher content knowlegde that did not find a significant effect on student gains in mathematics (Carnoy et al., 2010; Carnoy and Arends, 2012; Sheperd, 2015) found a positive impact on students learning in mathematics and reading (Bietenbeck et al, 2018; Bientebeck et al, 2022).

Furthermore, students ' teaching practices in Sub-Saharan Africa also account for the use of information and communication technology, focusing on enhancing the quality of subject teaching and learning in primary schools (Henessy et al, 2010; Graham et al, 2010). The authors emphasize that teachers must incorporate ICT into subject teaching and learning through contemporary pedagogical approaches (Henessy et al., 2010), but teachers may perceive technology integration as beneficial primarily when it enhances productivity and social influence (Graham et al, 2010).

However, earlier studies on teaching practices did not analyze a specific teaching practice (traditional teaching practices or modern teaching practices). The study on specific teaching practices has been conducted by Mosimege and Winnaar (2021) and Iyamuremye et al. (2021).

Iyamuremye et al. (2021) conducted a comprehensive review and meta-analysis of 20 years of African research, systematically investigating the effect of mathematics teaching approaches on student performance. Their findings establish that different teaching methodologies significantly affect students' mathematics performance. Notably, the use of concrete manipulatives emerges as the most effective teaching approach, demonstrating a substantial effect size. This strongly indicates that employing tangible objects to teach mathematical concepts can significantly enhance students' understanding and performance.

Mosimege and Winnaar (2021) found compelling evidence regarding the efficacy of two instructional strategies—problem solving with direct teacher guidance and teacher-teacher interaction—on grade 9 learner performance in South Africa. Their results undeniably show that these two strategies are significantly associated with improved student performance across four critical content domains: algebra, numbers, geometry, and data handling.

In developing countries, research on teaching practices is very limited, and few studies have investigated how these practices impact student achievement (Mosimege and Winnaar, 2021; Iyamuremye et al., 2021). Unlike developed countries, which often focus on modern or traditional teaching methods, teaching practices in developing countries primarily refer to instructional practices. These include teacher-teacher interactions, teacher-learner interactions, teacher explanations of content, problem-solving with direct teacher guidance, and problem-solving without direct guidance.

There are few studies examining the relationship between teaching practices and students outcome and none on cognitive skills. Research conducted in Sub-Saharan Africa has shown that the quality of teaching and the nature of teacher-student interactions significantly influence student outcomes (Carnoy et al., 2015; Arends et al., 2017; Iyamuremye, 2021).

In Botswana, factors such as the subject being taught, teacher training, and the use of textbooks significantly affect various teaching behaviors. Overall, teaching behavior in Botswana classrooms tends to be simplistic, utilizes few instructional tools, and is predominantly teacher-centered. Most communication occurs between the teacher and the entire class, and instructional practices are heavily reliant on didactic teaching. These pedagogical routines remain consistent over time. Additionally, the modest variations observed among Botswana teachers can primarily be attributed to external organizational factors, particularly curricular structures influenced by policy actions in centralized systems (Fuller et al., 1994).

 However, earlier studies conducted did not explore the link between didactic teaching skills and student outcomes, a gap that subsequent research has addressed. Ngware et al. (2014) employed mixed methods to find that teaching style is a crucial factor in explaining differences in academic performance among primary school students in Kenya. Carnoy et al. (2015) used a production function model to assess sixth-grade mathematics learning in three key African countries: Botswana, Kenya, and South Africa. Their analysis indicates that teaching quality has a direct impact on student achievement.

The authors found that higher levels of teacher mathematics knowledge lead to better mathematics teaching, particularly in South African schools. Furthermore, teachers with greater mathematics knowledge tend to cover more mathematics material in all three countries, although experienced teachers do not consistently provide increased coverage. The strongest relationship between teacher test scores and both teaching quality and student exposure to mathematics occurs in South Africa. This finding is important, suggesting that improving teacher mathematics knowledge in South Africa could have a more substantial effect on teaching quality and student exposure to mathematics than in Botswana and Kenya, where teachers scored higher on the test.

 Some studies have also examined classroom practices in South African schools (Hoadly, 2012; Arends et al., 2017). Hoadley's (2012) article reviews classroom-based studies to identify the existing knowledge base concerning teaching and learning in South African primary schools. In contrast, Arends et al. (2017) used a hierarchical linear model that considered both teacher and student levels to investigate the correlation between student achievement and specific teacher practices. The results indicated that practices such as teacher clarity, classroom discussion, feedback, formative assessment, problem-solving, metacognitive strategies, and collaboration significantly and positively impacted students' mathematics performance.

While some studies on the influence of teacher content knowledge did not find a significant effect on student gains in mathematics (Carnoy et al., 2010; Carnoy and Arends, 2012; Sheperd, 2015), other studies reported a positive impact on student learning in mathematics and reading (Bietenbeck et al., 2018; Bientebeck et al., 2022).

Furthermore, teaching practices in Sub-Saharan Africa also incorporate the use of information and communication technology (ICT), with a focus on improving the quality of subject teaching and learning in primary schools (Hennessy et al., 2010; Graham et al., 2010). The authors stress that teachers should integrate ICT into subject teaching and learning through contemporary pedagogical approaches (Hennessy et al., 2010), although teachers may view technology integration as beneficial mainly when it enhances productivity and social influence (Graham et al., 2010).

Previous studies on teaching practices did not focus specifically on traditional versus modern teaching methods. However, research by Mosimege and Winnaar (2021) and Iyamuremye et al. (2021) has addressed specific teaching practices. Iyamuremye et al. (2021) conducted a comprehensive review and meta-analysis of 20 years of research in Africa, systematically examining the impact of different mathematics teaching approaches on student performance. Their findings reveal that various teaching methodologies significantly influence students' performance in mathematics. Notably, the use of concrete manipulatives emerged as the most effective approach, demonstrating a substantial effect size. This suggests that incorporating tangible objects to teach mathematical concepts can greatly enhance students’ understanding and performance. Meanwhile, Mosimege and Winnaar (2021) provided compelling evidence regarding the effectiveness of two instructional strategies—problem-solving with direct teacher guidance and teacher-teacher interaction—on the performance of grade 9 learners in South Africa. Their results clearly indicate that these two strategies are significantly associated with improved performance across four key content areas: algebra, numbers, geometry, and data handling.

1. **Methodology / Estimation strategy**
	1. **Theoretical Framework**

The standard education production function is used as a theoretical framework to estimate the effect of teaching practices on cognitive skills in subsaharan Africa, as follows:

$Z\_{ijkc}=μ\_{i}+S\_{ijkc}^{'}β\_{ijkc}+T\_{jkc}^{'}γ\_{jkc}+TP\_{jkc}^{'}δ\_{jkc}+SC\_{jkc}^{'}φ\_{jkc}+ϑ\_{ijkc} $ (1)

Where student’s cognitive test score $i$, taught by teacher $j$, in subject ($k$= mathematics, language), in country $c$. $Z\_{ijkc}$ is determined by teacher’s teaching practices and by a set of other variables representing student’s $S\_{ijk}^{'}$, teachers $T\_{jk}^{'}$, and schools characteristics $SC\_{jk}^{'}$. The error term, $ϑ\_{ijkc}$, contains the effects of unobserved student, $ϵ\_{ic}$, teacher, $θ\_{jc}$, and school characteristics, $ρ\_{kc}$:

$ϑ\_{ijkc}=ϵ\_{ic}+θ\_{jc}+ρ\_{kc}+τ\_{ijkc}$ (2)

Estimating equation (1) using ordinary least squares leads to biased estimates due to selection effects and unobserved characteristics of students, teachers, and schools. At a national level, the sorting of students into schools or classrooms often depends on parents' preferences for specific teaching practices. For instance, parents may choose to enroll their children, who possess high unobserved abilities, in schools that emphasize particular teaching methods. Moreover, the education systems in our sample differ in various ways, and one unobserved factor may be correlated with both teaching practices and student cognitive assessments. Failing to address the sorting issue and the heterogeneity of different education systems could result in biased estimates due to these unobserved characteristics. To address the selection effect, a within-student, between-subjects approach that is corrected for endogeneity is applied.

* 1. **Model specification**

Building upon the foundational research of Aslam and Kingdon (2007), Dee (2007), Schwerdt and Wuppermann (2009), Klareven (2011), and Bietenbeck (2014, 2022), we address selection effects using a within-student, between-subject approach. By utilizing comprehensive data on teaching practices categorized by subject, we can effectively harness the variations in instructional methods to better understand their impact on student achievement. This approach allows us to analyze each student’s performance across different subjects while controlling for individual differences. Consequently, we are able to derive a pupil fixed-effects achievement function, which can be estimated as follows:

$Z\_{ijk}=μ\_{i}+S\_{ijk}^{'}β\_{ijk}+T\_{jk}^{'}γ\_{jk}+TP\_{jk}^{'}δ\_{jk}+\left(ϵ\_{i}+θ\_{j}+ρ\_{k}+τ\_{ijk}\right)$ (3)

Equation (3) account for students sorting into teaching practices across classrooms. But is still bias because of within-school sorting even though schools have two subjects in grade six. To remove the influence on constant student’s traits we are differencing between subjects (mathematics and language) and by assuming that school and student characteristics influence these test scores in a similar manner (Dee, 2007), we control for selection effects at the school and the student level.

The within student between subject approach is described as follow:

$∆Z\_{i}=(μ\_{m}-μ\_{l})+S\_{ijk}^{'}(β\_{ijm}-β\_{ijl})+T\_{jm}^{'}γ\_{jm}-T\_{jl}^{'}γ\_{jl}+TP\_{jm}^{'}δ\_{jm}-TP\_{jl}^{'}δ\_{jl}+ξ\_{i}$ (4)

Which is equivalent to:

$∆Z\_{i}=c\_{i}+ΔT\_{i}^{'}γ\_{i}+ΔTP\_{i}^{'}δ\_{i}+ξ\_{i}$ (5)

Where $∆Z\_{i}=Z\_{i,m}-Z\_{i,l}$, represents the difference between mathematics and language performance.

Equation (5) suggests that the characteristics of students and schools have an equal impact on student performance. However, it is also possible that these characteristics affect performance in different ways. To examine this further, we will estimate equation (4) as a robustness check.

The estimation of the effect of teaching practices on cognitive test scores, as described in equation (5), can be approached using a within-student, between-subject method. However, we assume that unobserved teaching characteristics are uncorrelated with both the teaching practices and the error terms. Additionally, $δ\_{i}$ is interpreted as a measure of the relationship between a teaching practice and student achievement that is not influenced by between- or within-school sorting effects (Schwerdt and Wuppermann, 2009).

 Teachers who emphasize certain teaching practices may possess unobserved characteristics that affect students’ cognitive skills. Bietenbeck (2014) notes that teacher motivation - an unobserved aspect of teaching practices - can enhance students’ test scores through channels other than the teaching practices index. This omitted variable presents a challenge for studies attempting to evaluate the impact of specific traits on student outcomes, introducing an endogeneity problem that complicates the analysis.

Generally, studies that focus solely on identifying “teacher quality” - the overall effect of a teacher—do not need to be concerned about this particular source of endogeneity, as they do not include individual teacher characteristics in their achievement gain equations (Aslam and Kingdon, 2007; Klareven, 2011). However, we must address this endogeneity issue because we incorporate specific teaching practices in our analysis and may also include teachers characteristics. While some studies control for this endogeneity by adding a set of teacher and classroom characteristics (Bietenbeck, 2013, 2014, 2022), others tackle the problem using the approach proposed by Altonji, Elder, and Taber (2005).

In this paper, we address endogeneity with instrumental variables or two-stage least squares methods, having first tested for endogeneity using the Hausman test. Moreover, due to the nature of the data, we will treat teaching practices as various instructional methods that teachers employ. Therefore, we will not differentiate the teaching practices variable and will use teaching practice variables as binary (dummy) variables. After analyzing the effects of teaching practices on cognitive skills, we will conduct robustness checks to verify the stability and reliability of our results in the data analysis and modeling process.

1. **Data**

The empirical analysis utilizes data from PASEC, an international assessment that evaluates the mathematics and reading knowledge of second and sixth-grade students. Initiated in 1991 by CONFEMEN’s Programme for the Analysis of Education Systems (PASEC), it initially focused on several French-speaking countries in sub-Saharan Africa and has been repeated every five years with a new sample of students.

PASEC evaluations began with a preliminary phase (1991–2012) during which national assessments, thematic evaluations, and cohort monitoring were conducted in various countries. Since 2012, PASEC has implemented five-year cycles of comparative international assessments of learning outcomes for second and sixth grades of primary education, utilizing a methodology that aligns with international standards. In 2014, PASEC conducted its first standardized assessment, labeled as PASEC2014, which included participation from ten sub-Saharan African countries: Benin, Burkina Faso, Burundi, Cameroon, Chad, Congo, Côte d’Ivoire, Niger, Senegal, and Togo. In 2019, the PASEC evaluation expanded to fourteen countries, adding Gabon, Guinea, Madagascar, and the Democratic Republic of Congo compared to the previous assessment.

Across its second waves up to 2019, a total of 14 countries participated in PASEC. This paper specifically focuses on the PASEC 2014 assessment, which evaluated sixth-grade students in mathematics and reading ([[4]](#footnote-4)). This was the first standardized comparative international assessment to use a methodology consistent with international standards. Notably, the 2014 assessment includes variables about teachers’ teaching approaches, from which we can derive insights on teaching practices. In contrast, the teacher questionnaire used in the 2019 assessment does not include these variables, instead focusing on teachers’ subject knowledge and teaching skills in both the language of instruction and mathematics. Therefore, the 2014 PASEC assessment is particularly appropriate to investigate the quality of teaching in schools across Sub-Saharan African countries.

PASEC employs a third-stage clustered sampling design to collect its data. In the first stage, schools are selected; in the second stage, classes are randomly sampled within these schools, and finally, students are chosen from these classes. Since only one class is sampled per surveyed level, it becomes impossible to distinguish data at the “school” and “class” levels. The grade six database consists of hierarchical data organized into two levels of sampling: the first level pertains to students, while the second level concerns the school and surveyed class.

All students in the selected classes take standardized tests in mathematics and reading, with background information gathered from both students and their teachers via questionnaires for each subject. Consequently, students are observed twice in the data – once for mathematics and once for reading – while teachers are typically observed with only one class. This setup is noteworthy because students in the same mathematics class also attend the same reading class, as primary school teachers handle all subjects. This indicates that there is minimal variation in teaching practices across subjects since students share the same teachers.

The PASEC standardized tests assess sixth-grade students' knowledge in mathematics and language through a combination of multiple-choice and open-response questions. Focusing on sixth-grade curriculum knowledge, rather than students' overall knowledge of mathematics and language, is crucial as it ensures that teaching practices can significantly influence student performance on the tests.

**3.1. Sample selection**

We analyzed data from one wave of the PASEC (2014) assessments. We excluded Madagascar, the Democratic Republic of Congo, Gabon, and Guinea from the original set of 14 countries due to the absence of data for these countries. Additionally, we removed students who could not be linked to a teacher and excluded those with missing test scores. As a result, the final sample consists of 31,213 students, with 31,188 teachers across 31,194 schools in 10 countries : Benin, Burkina Faso, Burundi, Cameroon, the Republic of the Congo, Ivory Coast, Niger, Senegal, Chad, and Togo.

Different socioeconomic groups are examined by studying both advantaged and disadvantaged children, using the student’s families socioeconomic index. This index is derived from responses to several questions posed to the students (derived to student’s questionnaire). It is based on their self-reports regarding the ownership of various goods, such as electricity, television, computer, radio, telephone, freezer, air conditioner, car, tractor, moped, running water tap, and latrine with running water.

The construction of this index followed the same development process as the test scores, utilizing item response theory. Similar to the achievement tests, item parameters were estimated using a calibration sample of 500 students from each country. However, the plausible values methodology was not employed to calculate the indices derived from the contextual questionnaires. The estimation of the subject parameters was carried out using the Maximum Weighted Likelihood Estimate, commonly referred to as the “WARN estimate”. To facilitate interpretation, these indices were transformed at the international level to obtain a mean of 50 and a standard deviation of 10.

For this study, the population will be divided into two groups based on the students’ socioeconomic level. The first group consists of children with a low socioeconomic level (SES below the average), while the second group includes students with a high socioeconomic level (SES above 50).

 In the later sections of this paper, the regressions include a comprehensive set of control variables derived from the questionnaires of students, teachers, and school directors. A summary of these variables is presented in *Table 7*, which reports descriptive statistics on student performance and instructional practices of teachers.

**3.2. Measuring teaching practices**

I use information from the PASEC teacher’s questionnaire to establish a set of teaching practice variables. The questionnaire asked teachers to select the teaching practices they utilize in their classrooms. Unlike other studies that rely on student questionnaires (Lavy, 2011; Bietenbeck, 2013) to derive teaching practices, this study focuses on a teacher questionnaire, which provides a more direct insight into teaching practices.

Moreover, the goal of the PASEC 2014 assessment is not specifically to measure traditional or modern teaching methods typically found in developed countries studies. In developing countries, teachers can choose from various teaching approaches, including Competence-Based Approaches (CBA), Situation-Adaptive Approaches (AAS), Teaching by Objectives (TBO), and large group-centered teaching (CT) (*Table 1*). The modern teaching approach is represented in the assessment through the use of small group work. In addition to exploring the different teaching approaches utilized by teachers, this study also examines how factors such as curriculum coverage, the number of lessons per week, and the teaching materials used for instruction influence students’ cognitive test scores.

The teacher questionnaire included questions about the objectives the teachers target in each subject, the number of lessons they conduct weekly for each subject, how often they engage students in fun activities, the extent of curriculum coverage, and the materials used for teaching ([[5]](#footnote-5)). These variables are included in the analysis to assess their impact on teaching practices.

**3.3. Measuring student cognitive skills (didactic skills)**

The mathematics test in the PASEC is designed around three cognitive domains, each reflecting distinct cognitive skills. The first domain, known as *the arithmetic or applying domain*, measures students’ ability to solve routine problems that are typically encountered in classroom exercises. The second domain, referred to as *the geometry and space or knowing domain*, focuses on students’ skills in perceiving, understanding, and manipulating shapes and objects in both two-dimensional and three-dimensional space. The third domain, called *the measurement and size or reasoning domain*, assesses students’ understanding of measurement units, their ability to use measurement tools, compare and order objects by size, and comprehend the relationships between length, volume, and area. This domain also evaluates how well students apply these concepts to real-world problems. Together, these skills are essential for developing numeracy, critical thinking, and problem-solving abilities.

The language/reading test in the PASEC is organized into two cognitive domains that reflect different cognitive skills. *The language comprehension domain* measures the ability to understand the meaning of spoken or written language. This involves grasping individual words, sentence structures, and the overall meaning of a text or conversation. It is a cognitive process that entails extracting meaning from language, whether through listening, reading, or other modalities. *The reading comprehension domain focuses* on the ability to understand and process written text ([[6]](#footnote-6)).

Each test question corresponds to one of these five domains and awards a certain number of points for correct answers. The distribution of questions and score points in each area is determined by education experts based on what they consider suitable for sixth-grade students. In the reading assessment, the score points are allocated as follows: 16% for language comprehension and 86% for reading comprehension. In mathematics, the distribution is 47.6% for the applying domain, 16.7% for the knowing domain, and 35.7% for the reasoning domain.

Analyzing these skills reveals that in mathematics, the knowing and applying domains reflect competencies that schools typically emphasize, which involve solving routine problems and memorization (*Table 2*). In contrast, the reasoning domain aligns with modern teaching practices that prioritize critical thinking and problem-solving. Although elements of contemporary pedagogy—such as the use of technology and collaboration—are not explicitly assessed, it is important to note that the PASEC evaluation devotes about 35.7% of score points to reasoning skills. This substantial emphasis on reasoning means the questions are crafted to evaluate students’ abilities to think critically, analyze information, solve problems, and draw logical conclusions. The PASEC assessment goes beyond simple fact recall, requiring students to demonstrate a deep understanding and application of concepts.

Similar to other international assessments, such as the PISA surveys, student performance on PASEC tests is estimated using the plausible values methodology, which follows item response theory. For each subject assessed (mathematics and language/reading), five plausible values are assigned to each student. Both scales are adjusted so that the international average is set at 500 with a standard deviation of 100, ensuring that each country contributes equally to this transformation. The PASEC dataset contains test scores for achievement across the five cognitive domains for both subjects. I standardize the overall test scores (five plausible values) to achieve a mean of zero and a standard deviation of one in the full sample.

**3.4. Other control variables**

In addition to our predictors, the study included several other exogenous variables related to student or family characteristics, and teacher/classroom characteristics.

1. **Preliminary Results:**
	1. **Descriptive statistics:**

**Cross-country differences in student cognitive tests scores and teaching practices**

 The objective of this study is to explore how variations in teaching practices influence the development of cognitive skills among different socio-economic and gender groups. Our focus is on instructional methods and classroom environments. The descriptive analysis of the variables used indicates that the mean cognitive test scores for language and mathematics indicate that students in sub-Saharan Africa exhibit low competency levels in both areas, as their scores fall below the minimum proficiency level (*Table 3 and Table 4*). However, a cross-country analysis reveals significant disparities among countries (*Table 6*).

 To better understand the level and variation in student cognitive test scores and teaching practices, we present average student test scores alongside diverse teaching methods used by teachers in each country in *Table 3*. The average language score in reading varies considerably between countries, ranging from 403.48 in Niger to 548.35 in Senegal. In mathematics, the average scores vary from 405.81 in Niger to 593.58 in Burundi (*Table 4*). According to the language of instruction proficiency scale for late primary, students in sub-Saharan Africa fall between level 1 (below minimum proficiency) and level 3 (above minimum proficiency).

 For language skills, students with low competency levels can develop decoding skills to understand isolated words from their daily lives or comprehend very short, disconnected sentences. However, they struggle to grasp the meaning of short and simple texts. In contrast, level 3 students can combine two pieces of information from a document and make simple inferences in narrative or informative texts. They can extract implicit information by interpreting connectors, anaphoras, and referents within the text, even locating specific information in lengthy and non-linear texts. No country achieved level 4 in reading proficiency.

 In mathematics, student competency levels range from level 1 (below proficiency) to level 2 (above proficiency). The alignment of cognitive tests with the mathematics proficiency scale indicates that students with low competencies do not adequately demonstrate the skills measured by these tests in the language of instruction. These students struggle with foundational knowledge and skills at level 1. On the other hand, students who are just above level 1 can answer brief questions using knowledge, application, and problem-solving skills. They can correctly respond to most factual questions and analyze situations to select appropriate solutions.

 There are also noticeable gender disparities in student cognitive test scores, as detailed in *Tables 6A* and *6B*. In literacy, girls outperformed boys in Burundi, Cameroon, Congo, Ivory Coast, and Togo, while boys outperformed girls in Benin, Burkina Faso, Niger, Senegal, and Chad. In mathematics, girls had higher scores than boys in Benin, Burundi, and Cameroon, whereas boys outperformed girls in Burkina Faso, Congo, Ivory Coast, Niger, Senegal, Chad, and Togo.

 Additionally, average families in Benin, Burkina Faso, Cameroon, Congo, Ivory Coast, and Senegal display a sufficient socioeconomic level, as indicated by an average index above 50, signifying ownership of essential goods such as electricity, televisions, computers, radios, telephones, freezers, air conditioners, cars, tractors, mopeds, running water taps, and latrines with running water. In contrast, average families in Burundi, Niger, Chad, and Togo are less affluent, scoring below 50.

 Also, most teachers in the sample reported using a competency-based approach, followed by a teaching-by-objectives methodology (*see Table 1*). The large group-centered teaching method was the least used among teachers. Additionally, many teachers reported incorporating small groups during instruction. Teaching approaches differ significantly between countries. The competency-based approach is predominantly used in five countries: Benin, Cameroon, Ivory Coast, Senegal, and Chad. Teaching by objectives is more common in Burundi, Congo, Niger, and Togo, whereas large group-centered teaching is observed mainly in Burkina Faso. It's also important to note that although each country primarily adopts one teaching approach, all four approaches are utilized across countries. *Table 7* summarizes statistics for our sample, which comprises 31,213 students across ten countries. On average, students are 12.78 years old, and approximately 38.25 percent have literate parents and demonstrate a sufficient socioeconomic level.

The investigation of how variations in teaching practices influence the development of cognitive skills among different socio-economic and gender groups is done in the following lines using the fixed effect approach.

***Annexes:***

*Table 1: Descriptive statistics: Teaching practices:*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Teaching approach | Mean | Std. Dev | Min | Max |
| *Competence based approach (CBA)* | .6530094 | .4760204 | 0 | 1 |
| *Approached adapted to the situation (AAS)* | .4503538 | .4975381 | 0 | 1 |
| *Teaching by Objectives (TBO)* | .6239025 | .484413 | 0 | 1 |
| *Large group centered teaching (CT)* | .3847205 | .4865379 | 0 | 1 |
| *Small Groups (SG)* | .8825784 | .3219272 | 0 | 1 |

*Table 2: Areas evaluated by PASEC (2019) in Reading and Mathematics on sixth grade*

|  |  |
| --- | --- |
| **Variables** | **Skills** |
| **language/reading** | **Mathematics** |
| **Areas assessed****(02)** | **Reading Support** | **Test composition** | **Areas assessed****(03)** | **Test composition** |
| Areas evaluated by the PASEC Survey | **Comprehension of isolated words and sentences areas**focuses on student’s ability to achieve reading fluency, to gradually understand the meaning of sentences and texts, and expand their vocabulary through exercises requiring students to read narrative and informative texts as well as documents, and then extract information, perform simple inferences, and interpret and combine information (Isolated pictures, words and sentences). | Isolated images, words and sentences | 16% | **Arithmetic area** measures student’s competency in solving routines problems which will typically have been standard in classroom exercises. The arithmetic area assesses students with reference to the understanding of numbers: knowledge and understanding of the sequence of operations and of the properties of the four operations; and operations on numbers such as adding, subtracting, multiplying and dividing. They were also assessed through the understanding of decimals and percentages | 47.6% |
|  | **Reading Comprehension**area enables students to read autonomously in a variety of everyday situations and thus develop their knowledge and participate in society by assessing reading exercises focusing on discovering the explicit meaning of isolated words and sentences | Narrative texts (39%), Informative tests and documents (45%) | 86% | **Measurement and size area measure** Skills relating to measurements and sizes were assessed with reference to the knowledge and understanding of units of measurement for length, mass, capacity, angle and duration, and the conversion of these measurement units. They were also assessed through calculations of size (length, duration, mass, capacity, angle, area, volume) in different contexts, using plane geometric figures (triangles, rectangles, squares, parallelograms, disks) and solids (cubes or rectangular parallelepipeds). | 35.7% |
|  |  |  |  | Geometry and spacearea Skills relating to geometry and space were assessed through exercises involving recognition of the properties of two or three-dimensional geometric shapes, geometric relations and transformations, and spatial position and representation.  | 16.7% |
| Skills targeted in the survey | reading; written comprehension; written expression; Spelling vocabulary, grammar and syntax, listening comprehension, oral expression |  |  |  |  |
|  |  |  |  |  |  |

*Table 3: Students’ Cognitive Skills tests scores in language by country*

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Countries | Number of observations | Mean | Std. Dev | Min | Max |
| 1= BN | 3,033 | 523.4353 | 96.98856 | 200.3985 | 821.2378 |
| 2= BFA | 3,416 | 531.6464 | 78.91909 | 218.2924 | 801.8143 |
| 3= BDI | 3,461 | 525.4087 | 46.49419  | 339.2055 | 786.8944 |
| 4= CMR | 3,817 | 517.4974 | 100.6506 | 229.0443  | 820.4658 |
| 5= CGO | 2,673 | 503.3958 | 88.06129 | 244.6734 | 810.7813 |
| 6= IC | 2,972 | 516.9856  | 93.72264 | 242.4394 | 789.119 |
| 7= NR | 3,196 | 403.4806 | 75.90851 | 120.0885 | 717.1156 |
| 8= SNL | 2,905 | 548.3514 | 103.0488 | 165.4042  | 794.3755 |
| 9= CHD | 2,484 | 432.4651 | 79.36886 | 164.763  | 709.353 |
| 10= TGO |  3,256 | 497.3337 | 90.69457 | 260.2873  | 778.7189 |
| Total | 31,213 | 505.8671 | 95.78036 | 120.0885 | 821.2378 |

*Table 4: Students’ Cognitive Skills tests scores in mathematics by country*

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Countries | Observations | Mean | Std. Dev | Min | Max |
| 1= BEN | 3,033 | 496.906  | 87.40172  | 153.5819  | 772.6834 |
| 2= BFA | 3,416 | 539.4743 | 84.71162  | 249.8716  | 814.3619 |
| 3= BDI | 3,461 | 593.5893 | 60.09833  | 331.4973  | 852.2568 |
| 4= CMR | 3,817 | 489.4967 | 90.94863 | 216.4821 | 789.6365 |
| 5= CGO | 2,673 | 481.4068 | 72.33386 | 279.202 | 723.7834 |
| 6= IC | 2,972 | 475.6612 | 68.43824 | 287.9887 | 686.7521 |
| 7=NR | 3,196 | 405.8149 | 72.66775 | 121.0474 | 767.5475 |
| 8= SNL | 2,905 | 546.5738 | 99.76362 | 146.1139 | 784.4073 |
| 9= CHD | 2,484 | 450.9085 | 76.85107 | 214.4399  | 679.095 |
| 10= TGO | 3,256 | 520.1686 | 99.7439 | 253.5748 | 827.0197 |
| Total  | 31,213 | 503.3101  | 95.08443 | 121.0474  | 852.2568 |

*Table 5: Student’s socio-economic level index by country*

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Countries | Obs | Mean | Std. Dev | Min | Max |
| 1=BEN | 3,000 | 52.42337 | 9.010824 | 17.54449  | 88.34007 |
| 2=BFA | 3,404 | 50.17284 | 7.518592 | 26.38755 | 88.34007 |
| 3=BDI | 3,425 | 43.44598 | 6.712122 | 17.54449 | 88.34007 |
| 4=CMR | 3,715 | 52.96115 | 9.138726 | 17.54449 | 88.34007 |
| 5=CGO | 2,622 | 54.01412 | 10.02118 | 17.54449 | 87.40678 |
| 6=IC | 2,957 | 52.2671 | 8.459743 | 17.54449 | 88.34007 |
| 7=NG | 3,152 | 45.00697 | 11.37878 | 17.54449 | 88.34007 |
| 8=SNL | 2,885 | 55.13136 | 9.09661 | 17.54449  | 88.34007 |
| 9=CHD | 2,423 | 45.60179 | 10.57988 | 17.54449 | 88.34007 |
| 10=TGO | 3,240 | 48.9526  | 9.394587 | 17.54449 | 79.8278 |
| Total | 30,823 | 50.05725 | 9.623763 | 17.54449 | 88.34007 |

*Table 7:*  *Summary Statistics: student, teacher, and school characteristics*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Variables | Mean | Std. Dev. | Min | Max |
|  |  |  |  |  |
| *Cognitive Skills tests scores* |  |  |  |  |
| Language | 505.8671 | 95.78036 | 120.0885 | 821.2378 |
| Mathematics | 503.3101 | 95.08443 | 121.0474 | 852.2568 |
|  |  |  |  |  |
| *Student’s and family characteristics* |  |  |  |  |
| Age | 12.78322 | 1.67154 | 8 | 25 |
| GenderMale =1 (recode this to female) | .5308077 | .499058  | 0 | 1 |
| Parent’s level of education | .3825506 | .4860187 | 0 | 1 |
| Socioeconomic level of student’s families Index | 50.05725 | 9.623763 | 17.54449 | 88.34007 |
|  |  |  |  |  |
| *Teachers’ characteristics* |  |  |  |  |
| Teacher is female | .2161533 | .4116266  | 0 | 1 |
| Teacher’s age | 38.96963 | 7.865624 | 19 | 67 |
| Teacher is aged 19-29 | .9817677 | .1337925 | 0 | 1 |
| Teacher is aged 30-49 | .002375 | .048677  | 0 | 1 |
| Teacher is older than 50 | .0158573 | .1249253 | 0 | 1 |
| Teacher’s experience  | 12.70224 | 8.200226 | 0 | 47 |
| Teacher’s first year teaching | .0077335 | .0876009 | 0 | 1 |
| Teacher experience is <5 | .1484161 | .3555176  | 0 | 1 |
| Teacher experience is 5-9 | .2763643 | .4472063 | 0 | 1 |
| Teacher experience is 10-24 | .4576431 | .4982106 | 0 | 1 |
| Teacher experience is >25 | .1098431 | .3126991 | 0 | 1 |
| Teacher has a certification |  |  |  |  |
| Index of classroom resources | 50.91984 | 9.895143 | -6.842488 | 79.22883 |
| Teachers has a postgraduate degree |  |  |  |  |
| Teacher covered the curriculum | .6656733 | .4717622 | 0 | 1 |
|  |  |  |  |  |
| *English teaching approach* |  |  |  |  |
| Average English lessons per week | 10.35676 | 4.807995 | 0 | 36 |
| Teaching materials:  |  |  |  |  |
| - Teaching guide |  |  |  |  |
| -Teaching sheet |  |  |  |  |
| -Old Courses |  |  |  |  |
| -School manuals |  |  |  |  |
| -Curricula |  |  |  |  |
| -Internet |  |  |  |  |
| Fun activities |  |  |  |  |
|  |  |  |  |  |
| *Mathematics teaching approach* |  |  |  |  |
| Average mathematics lessons per week | 5.966373 | 2.470921  | 0 | 25 |
| Teaching materials |  |  |  |  |
| -Teaching guide |  |  |  |  |
| -Teaching sheet |  |  |  |  |
| -Old Courses |  |  |  |  |
| -School manuals |  |  |  |  |
| -Curricula |  |  |  |  |
| -Internet |  |  |  |  |
| Fun activities |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
| *School characteristics* |  |  |  |  |
| Public school | .8673986 | .3391491 | 0 | 1 |
| Private school | .0284206  | .1661743 | 0 | 1 |
| Town | .4125181 | .4922953  | 0 | 1 |

*Table6: Teaching Approaches, Average Students’ Cognitive Skills tests, and student’s gender by country and by subject*

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | 1= BEN | 2=BFA | 3=BDI | 4=CMR | 5=CGO | 6=IC | 7=NR | 8=SEN | 9=CHD | 10=TGO | Total |
| Teaching approaches |  |  |  |  |  |  |  |  |  |  |  |
| CBA | 3,033 | 436 | 1,265 | 3,523 | 576 | 2,681 | 1,626 | 2,749 | 2,069 | 1,006 | 18,964 |
| AAS | 1,527 | 748 | 2,031 | 2,300 | 210 | 1,125 | 814 | 2,071 | 524 | 888 | 12,238 |
| TBO | 1,090 | 1,650 | 2,874 | 3,094 | 2,432 | 1,152 | 2,801 | 1,946 | 1,387 | 2,231 | 20,657 |
| CT | 723 | 2,665 | 1,733 | 1,633 | 370 | 123 | 425 | 1,271 | 540 | 776 | 10,259 |
| SG | 3,014 | 3,228 | 2,891 | 3,503 | 2,050 | 2,650 | 2,925 | 2,565 | 1,571 | 2,955 | 27,352 |
|  |  |  |  |  |  |  |  |  |  |  |  |
| Cognitive Skills |  |  |  |  |  |  |  |  |  |  |  |
| Language | 523.4353 | 531.6464 | 525.4087 | 517.4974 | 503.3958 | 516.9856 | 403.4806 | 548.3514 | 432.4651 | 497.3337 | 505.8671 |
| Mathematics | 496.906 | 539.4743 | 593.5893 | 489.4967 | 481.4068 | 475.6612 | 405.8149 | 546.5738 | 450.9085 | 520.1686 | 503.3101 |
|  |  |  |  |  |  |  |  |  |  |  |  |
| Students’ Gender |  |  |  |  |  |  |  |  |  |  |  |
| Boys | 1,400 | 1,683 | 1,871 | 2,006 | 1,375 | 1,652 | 1,768 | 1,339 | 1,672 | 1,792 | 16,558 |
| Girls | 1,633 | 1,733 | 1,590 | 1,811 | 1,298 | 1,320 | 1,428 | 1,566 | 812 | 1,464 | 14,655 |
| Total | 3,033 | 3,416 | 3,461 | 3,817 | 2,673 | 2,972 | 3,196 | 2,905 | 2,484 | 3,256 | 31,213 |

*Table 6A: Cognitive Skills tests scores in language by gender and by country*

|  |  |  |
| --- | --- | --- |
|  | **Girls** | **Boys** |
| Countries | Obs | Weight | Mean | Std. Dev | Min | Max | Obs | Weight | Mean | Std. Dev | Min | Max |
| 1 | 1,633 | 104821.683 |  520.1288 | 93.16499 | 235.1979 | 815.2571 | 1,400 | 94053.3763 | 527.1203 | 100.985 | 200.3985 | 821.2378 |
| 2 |  1,733 | 161873.221 | 529.6486 | 76.0744 | 218.2924 | 782.8536 | 1,683 | 155973.602 | 533.7198 | 81.73791 | 225.1081 | 801.8143 |
| 3 | 1,590 | 95692.8927  | 531.7975 | 45.81652 | 361.6724 | 783.1061 | 1,871 | 116124.144 | 520.1441 | 46.40051 | 339.2055 | 786.8944 |
| 4 | 1,811 | 99254.8326 | 527.1544 | 102.0065 | 268.7101 | 820.4658 | 2,006 | 118010.471 | 509.3751 | 98.79191 | 229.0443 | 787.3574 |
| 5 | 1,298 | 31797.3461 | 508.4344 | 87.66581 | 262.4241 | 810.7813 | 1,375 | 32097.6589 | 498.4043 | 88.20045 | 244.6734 | 790.3088 |
| 6 | 1,320 | 174285.202 | 519.5682 | 96.55368 | 252.666 | 789.119 | 1,652 | 206380.502 | 514.8046 | 91.237 | 242.4394 | 769.3523 |
| 7 | 1,428 | 74326.728 | 400.0795 | 76.13045 | 120.0885 | 717.1156 | 1,768 | 97110.6849 | 406.0838 | 75.65583 | 140.6554 | 702.8436 |
| 8 | 1,566 | 88101.7282 | 546.2849 | 104.0065 | 165.4042 | 791.4651 | 1,339 | 78821.39  | 550.6612 | 101.9561 | 258.6986 | 794.3755 |
| 9 | 812 | 50128.7263 | 420.9472 | 78.99181 | 164.763 | 633.8193 | 1,672 | 94579.9817 | 438.5697 | 78.91387 | 194.8918 | 709.353 |
| 10 | 1,464 | 72683.9945 | 500.3966 | 92.65102 | 270.0753 | 778.7189 | 1,792 | 84960.469 | 494.7134 | 88.92963 | 260.2873 | 769.6348 |
| Total | 14,655  | 952966.354  | 509.4892 | 96.35526 | 120.0885 | 820.4658 | 16,558 | 1078112.28 | 502.6654 | 95.15748  | 140.6554  | 821.2378 |

*Table 6B: Cognitive Skills tests scores in mathematics by gender and by country*

|  |  |  |
| --- | --- | --- |
|  | **Girls** | **Boys** |
| Countries | Obs | Weight | Mean | Std. Dev | Min | Max | Obs | Weight | Mean | Std. Dev | Min | Max |
| 1 | 1,633 | 104821.683 | 499.527 | 85.47006 | 230.653 | 756.3401 | 1,400 | 94053.3763 | 493.985 | 89.44501 | 153.5819 | 772.6834 |
| 2 | 1,733 | 161873.221 | 532.9575 | 81.5291 | 249.8716 | 814.3619 | 1,683 | 155973.602 | 546.2375 | 87.40457 | 272.3146 | 803.2349 |
| 3 | 1,590 | 95692.8927 | 611.7552 | 58.15754 | 418.6646 | 852.2568 | 1,871  | 116124.144 | 578.6196 | 57.50237 | 331.4973 | 837.7847 |
| 4 | 1,811 | 99254.8326 | 490.6679 | 92.28142 | 241.9203 | 785.6517 | 2,006 | 118010.471 | 488.5116 | 89.82273 | 216.4821 | 789.6365 |
| 5 | 1,298 | 31797.3461 | 473.8392 | 74.7077 | 294.3102 | 723.7834 | 1,375 | 32097.6589 | 488.9035 | 69.11804 | 279.202 | 714.7439 |
| 6 | 1,320 | 174285.202 | 468.1838 | 67.98528 | 289.0975 | 660.2704 | 1,652 | 206380.502 | 481.9757 | 68.20376 | 287.9887 | 686.7521 |
| 7 | 1,428 | 74326.728 | 401.728 | 69.26629 | 121.0474 | 734.6725 | 1,768 | 97110.6849 | 408.9429 | 75.0359 | 142.3248 | 767.5475 |
| 8 | 1,566 | 88101.7282 | 537.6879 | 98.1177 | 146.1139 | 782.0964 | 1,339 | 78821.39 | 556.506 | 100.6832 | 222.4882 | 784.4073 |
| 9 | 812 | 50128.7263 | 436.5905 | 75.15147 | 219.8663 | 650.0946 | 1,672 | 94579.9817 | 458.4973 | 76.68332 | 214.4399 | 679.095 |
| 10 | 1,464 | 72683.9945 | 515.8308 | 98.6791 | 276.2564 | 827.0197 | 1,792 | 84960.469 | 523.8796 | 100.5256 | 253.5748 | 819.3876 |
| Total | 14,655 | 952966.354  | 502.796 | 96.19805 | 121.0474 | 852.2568 | 16,558 | 1078112.28 | 503.7646 | 94.08967 | 142.3248 | 837.7847 |

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1. The corresponding author is currently an Associate Lecturer at the Catholic University of Central Africa. Corresponding author email address: cecilencn@outlook.com [↑](#footnote-ref-1)
2. A study by Kane et al. (2011) examined how teacher practices impact student achievement by combining classroom observations with student achievement data. Their findings showed that improving a teacher's rating from "Basic" to "Proficient" or from "Proficient" to "Distinguished" correlates with student achievement gains of about one-sixth to one-fifth of a standard deviation. For instance, a student in the 50th percentile in math and reading with a lower-rated teacher is expected to fall four percentile points behind in math and five points in reading compared to a peer with a higher-rated teacher by the end of the year. [↑](#footnote-ref-2)
3. Bietenbeck (2014) examined the impact of traditional and modern teaching practices on students' cognitive skills using econometric estimation that controlled for student fixed effects. The study found that these teaching methods promote different cognitive skills. Similarly, Lavy (2016) analyzed the relationship between teaching practices and student achievement in Israeli primary and middle schools. The study identified two key practices that enhance achievement: emphasizing knowledge and comprehension, especially for girls and low socioeconomic students, and promoting analytical and critical skills, particularly for students from educated families. Additionally, factors like transparent evaluation and timely feedback improved cognitive gains for boys. However, efforts to foster independent study did not positively impact learning outcomes. These findings were consistent across various methods of analyzing student responses. [↑](#footnote-ref-3)
4. Choosing sixth grade students for analysis rather than second-grade students, is justifiable due to the cognitive developmental maturity necessary for understanding and participating in complex data analysis. Sixth grade students possess a greater capacity for abstraction, logic, and mathematical reasoning compared to their younger counterparts. [↑](#footnote-ref-4)
5. In case of objectives targeted by teachers in each subject, Two objectives targeted by the teachers (reading; written comprehension; written expression; Spelling vocabulary, grammar and syntax, listening comprehension, oral expression) for English or French. The number of lessons the teachers do per week in Mathematics (Count, properly reckon and assess quantities; Know operation rules; Know geometrical forms and geometrical calculation formulas; Calculate mentally; Apply, resolve operations; Reason, solve problems (in geometry/ numeration / measurement)) and English (reading; written comprehension; written expression; Spelling vocabulary, grammar and syntax, Listening comprehension, oral expression) [↑](#footnote-ref-5)
6. **Language comprehension domain** and **reading comprehension domain** reflect different cognitives skills. **Reading comprehension** involves understanding written text, which relies on skills like decoding, fluency, vocabulary, and comprehension strategies such as summarizing, inferencing, and predicting. The foundational skills are: summarizing, decoding, fluency, vocabulary, making inferences, main idea, comparing and constrating, monitoring comprehension, questioning, sequency, analyzing story elements, visualising, inferencing, make predictions, ask questions, generate question, identify and summarize key ideas. Whereas

 **Language comprehension** relies on vocabulary knowledge, grammatical knowledge, backgroung knowledge, inference, text structure. [↑](#footnote-ref-6)