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The Impact of School Infrastructure on Academic Performance in Cameroon: Empirical Evidence From Cameroon

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Abstract: This study examines the impact of school infrastructure on pupils' academic performance in Cameroon, addressing concerns over persistently low schooling rates and educational outcomes in primary schools. Using cross-sectional secondary data from the PASEC survey conducted across ten Francophone African countries, covering 31,213 pupils from 671 schools in Cameroon. The data were analyzed using descriptive statistics and robust Ordinary Least Squares (OLS) regression. The findings reveal that school infrastructure has a significant positive effect on pupils' academic performance, suggesting that improvements in classroom conditions, access to educational resources, and overall school facilities correlate with better academic outcomes. Additionally, several control variables, including electricity at home, parental involvement in education, access to study guides, and the availability of basic learning materials, also show a positive relationship with academic performance. However, certain factors, such as school canteens, catch-up lessons, and WiFi access at home, exhibit unexpected negative effects on pupils' performance, indicating potential distractions or inefficiencies in their implementation. The study concludes that investment in school infrastructure is crucial for enhancing educational quality in Cameroon. It emphasizes the need for targeted interventions focusing on classroom construction, the provision of teaching materials, and inclusive infrastructure to support diverse student needs. From a policy perspective, the Cameroonian government should address urban-rural disparities through decentralization, ensuring that local authorities play an active role in school infrastructure development. The findings suggest that while digitalization is not yet a priority, fundamental infrastructure improvements, such as classrooms, desks, potable water, and libraries, should be prioritized to create a more conducive learning environment.

Keywords: School Infrastructure, Academic Performance, Primary Education, Cameroon, Educational Resources, Policy Implications, Decentralization.

1. Introduction

The structure and scale of educational institutions have traditionally been influenced by the concept of economies of scale, which suggests that larger schools benefit from reduced costs per student. In 1959, James Bryant Conant, then President of Harvard University, published a seminal work identifying small high schools as a major issue in American education (Conant, 1959). In response to his findings, several large-scale high schools were constructed. However, more recent research challenges this perspective, suggesting that smaller schools are often associated with better academic outcomes. Optimal small educational institutions provide a supportive learning environment in which educators, learners, and parents function as a close-knit community, actively addressing concerns related to education quality, inclusivity, governance, and a nurturing school atmosphere.

The educational landscape has evolved significantly over the years. Since the 1980s, the term "school" has been used to refer to a formal institution dedicated to structured instruction under the guidance of educators. Meanwhile, the term "environment" encompasses not only the physical setting in which learning occurs but also the broader social and psychological conditions that influence students' educational experiences. Mick (2011) defines the school environment as the extent to which the school setting ensures students' safety, well-being, and academic engagement. This definition includes elements such as school infrastructure, the quality of instructional spaces, access to physical and mental health support services, and the fairness and effectiveness of school discipline policies.

In alignment with this perspective, research has consistently demonstrated that school infrastructure plays a critical role in shaping the quality of education and students' academic performance. The availability of adequate instructional facilities is fundamental to effective teaching and learning. While it is widely acknowledged that teaching facilitates learning, it is equally true that students can engage in self-directed learning without direct instruction. Oni (1992) emphasizes that school infr-

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-astructure is crucial to the strategic operations of educational institutions, significantly affecting their efficiency and effectiveness.

Salau (2001) highlights that a well-equipped learning environment fosters motivation and enhances students' academic achievement. Similarly, Umoh (2006) asserts that learning outcomes improve in educational settings that provide adequate infrastructure and well-trained teaching staff. However, Onyekwellu (2002) argues that governments alone cannot shoulder the financial burden of providing all necessary educational resources. As a result, parents and stakeholders, through platforms such as the Parents' Teachers' Association (PTA), should contribute to the provision of infrastructure, equipment, and instructional materials. Such collaborative efforts have the potential to significantly improve educational quality.

Education is a cornerstone of societal progress and human development, with access to quality education being a crucial determinant of both individual and national success. While several factors influence academic performance, one often overlooked element is school infrastructure. In high-income countries, where educational resources are abundant, the impact of infrastructure on learning outcomes is sometimes underestimated. However, emerging research indicates that the quality of school facilities directly influences students' educational experiences and achievements.

Educational research has increasingly recognized the learning environment as a critical determinant of student success (Biddle & Berliner, 2002). The concept of "school climate" refers not only to teaching quality and curriculum design but also to the physical conditions in which students learn (Cohen, McCabe, Michelli, & Pickeral, 2009). Thus, it is essential to examine how school infrastructure affects student motivation, engagement, and overall well-being, as these factors significantly contribute to learning outcomes.

In Africa, where educational infrastructure varies widely across regions, its role in shaping academic performance is even more pronounced. The continent faces challenges such as disparities in school access, resource limitations, and overcrowded classrooms (Mundy & Haggarty, 2007). In this context, understanding the impact of school infrastructure on student performance is crucial. Adequate and well-maintained facilities create an environment conducive to effective teaching and learning, whereas poor infrastructure can hinder students' progress (Owusu and Mariwah, 2017).

Research has shown that school infrastructure influences student motivation, attendance, and academic success (UNESCO, 2016). Essential amenities such as clean water, electricity, and sanitation facilities directly affect students' health and, consequently, their ability to attend and perform well in school (UNICEF, 2018). Given the importance of education in driving economic development and social mobility, investigating the relationship between school infrastructure and academic performance is a crucial endeavor. This study seeks to provide empirical insights to inform policymakers, educators, and stakeholders on the role of infrastructure investment in improving education outcomes in Africa.

In Cameroon, as in many African countries, inadequate school infrastructure presents a significant challenge to student performance. Observations highlight several key issues in Cameroonian schools. First, classroom overcrowding remains a major obstacle. Large class sizes hinder effective teaching, limit individualized attention, and reduce student engagement. Second, school facilities vary significantly—some schools have modern, well-equipped buildings, while others lack basic resources such as desks, chairs, and functioning restrooms (Kum, 2020). Substandard infrastructure can create an uncomfortable and demotivating learning environment, ultimately affecting students' academic performance.

Overcrowded classrooms and inadequate resources can lead to lower academic achievement as pupils struggle to grasp concepts and fall behind in their studies. Additionally, the deteriorating condition of school buildings discourages regular attendance, contributing to high dropout rates, especially among disadvantaged groups. Disparities in school infrastructure further widen the educational gap between urban and rural areas, reinforcing socio-economic inequalities. In light of these challenges, this study investigates the effects of school infrastructure on academic performance in Cameroonian primary schools.

Following the 2000 UN Declaration on Universal Primary Education, global efforts were made to expand access to schooling. Member states committed to achieving the Millennium Development Goals (MDGs) by 2015, with Goal 2 focused on achieving universal primary education and gender equality at all education levels. The Sustainable Development Goals (SDGs) later reinforced this commitment, with SDG 4 emphasizing inclusive, equitable, and quality education for all by 2030.

Despite Cameroon's progress in school enrollment, significant challenges remain. Although primary school enrollment increased from 45.99% in 2016 to 77% in 2022 (MINEDUB, 2022), many children still lack access to quality education. Performance trends in national exams also highlight inconsistencies, with fluctuating success rates for the Certificat d'Études Primaires (CEP) and the First School Leaving Certificate (FSLC). Completion rates have declined from 74.24% in 2012 to 65.5% in 2019 (MINEDUB, 2019). These figures raise concerns about the effectiveness of current educational policies and infrastructure investments.

Given the importance of school infrastructure in supporting student achievement, this study aims to examine how different physical and psychological aspects of the learning environment affect pupils' academic performance in Cameroon. The increasing availability of modern infrastructure, such as better classrooms,

libraries, and laboratories, suggests potential improvements in learning conditions. However, this study uniquely highlights a surprising negative correlation between academic performance and factors such as WiFi availability, canteen services, and catch-up lessons. The researcher explores possible explanations for these unexpected findings, considering Cameroon's socio-cultural diversity, bilingual education system, and regional differences.

Cameroon's educational system is highly complex, influenced by its French and English sub-systems and four distinct socio-cultural zones. This diversity makes it unique within the CONFEMEN education network, meaning that findings from similar studies in other African countries may not be directly applicable. This study, therefore, provides valuable insights tailored to Cameroon's specific educational context, contributing to a deeper understanding of how school infrastructure influences academic success in diverse learning environments.

2. Literature Review

2.1. Theoretical Literature Review

The theory of school climate, as proposed by Cohen et al. (2009), suggests that the overall quality and atmosphere within a school significantly influence the experiences and outcomes of students, teachers, and staff. It emphasizes that the physical conditions of schools, interpersonal relationships within the school community, and the overall culture of the institution are fundamental components of the educational environment. According to this theory, a positive school climate fosters engagement, motivation, and a sense of belonging among students, which in turn enhances academic performance. Additionally, a supportive school climate benefits teachers by promoting job satisfaction, collaboration, and effective teaching practices, ultimately contributing to teacher retention and professional development.

A well-maintained and safe school infrastructure is crucial for fostering a positive school climate, as it enhances students' feelings of security and well-being. Strong relationships and positive interactions among students, teachers, and administrators further reinforce this conducive learning environment. However, one limitation of this theory is the lack of a universally accepted and standardized definition of "school climate," making it subjective and context-dependent, which poses challenges in measurement and comparison across different educational settings. Despite these limitations, Cohen et al.'s theory remains valuable for understanding the importance of school climate in shaping educational experiences. It underscores the role of positive relationships, a supportive culture, and safe facilities in fostering effective teaching and learning, offering critical insights for educators, researchers, and policymakers.

Coleman's (1988) theory of social capital in the creation of human capital highlights the role of social networks and relationships in shaping educational and economic outcomes. Social capital, defined as the resources embedded in social structures and interpersonal relationships, plays a pivotal role in human capital formation, influencing educational achievement, economic mobility, and overall societal well-being. The theory suggests that individuals with access to strong social networks, such as family, peers, and mentors, are more likely to acquire the knowledge and skills necessary for academic and professional success. Additionally, Coleman asserts that social capital is transferable across different contexts; for instance, the benefits gained through family support can positively influence educational or professional settings.

Social capital facilitates the exchange of information, resources, and opportunities, reinforcing academic success. A student with engaged parents may benefit from access to educational resources such as books or tutoring, ultimately improving academic achievement. Similarly, individuals with strong social networks may experience enhanced career prospects due to easier access to job opportunities and professional guidance. Empirical studies support this theory, demonstrating that students with involved parents tend to perform better academically (Henderson & Mapp, 2002). However, one of the key challenges of this theory is the difficulty in accurately quantifying and measuring social capital. Its impact varies based on cultural, economic, and institutional factors, making it challenging to generalize findings across diverse settings. Despite these limitations, Coleman's work remains fundamental in understanding the role of social capital in education, highlighting the importance of relationships and networks in shaping students' academic and economic outcomes.

Albert Bandura's Social Learning Theory (1977) posits that individuals learn not only through direct experiences but also by observing and imitating the behaviors of others. It suggests that learning is a cognitive process influenced by external stimuli, observational learning, and self-regulation. The theory underscores the role of modeling, reinforcement, and self-efficacy in shaping behavior and development. Observational learning, according to Bandura, involves four key processes: attention, retention, reproduction, and motivation. Individuals actively observe behaviors in their environment, retain this information, replicate the behavior, and are motivated by positive reinforcement.

An example of this theory in action is a child learning polite speech by observing their parents' courteous language and the positive responses they receive. This process illustrates how individuals acquire behaviors by paying attention to role models, retaining observed actions, and reproducing them in appropriate contexts. The theory also introduces the concept of self-efficacy, which refers to an individual's belief in their ability to

perform specific tasks or achieve particular goals. A student with high self-efficacy in mathematics, for instance, is more likely to engage in and persist with math-related tasks, as they believe in their capacity to succeed.

Despite its contributions to understanding human learning, Bandura's theory tends to emphasize cognitive and environmental influences while underestimating the potential role of biological factors, such as genetics and neurological processes. Additionally, the theory may oversimplify motivation by focusing primarily on external reinforcement and rewards, overlooking the complexity of intrinsic motivation and individual differences in learning. Nonetheless, Social Learning Theory remains influential in psychology and education, emphasizing the significance of social interactions, self-regulation, and self-efficacy in learning. While it provides critical insights into how individuals acquire behaviours through observation and modelling, it should be considered alongside other theories to develop a more comprehensive understanding of human learning processes.

2.2. Empirical Literature Review

2.2.1. The Relationship Between School Infrastructure and Academic Performance

School infrastructure has been widely recognized as a key determinant of students' academic performance, influencing both learning conditions and overall educational outcomes (UNESCO, 2016). While several studies confirm a positive correlation between well-equipped schools and student achievement, infrastructure disparities remain a major challenge in developing countries, particularly in sub-Saharan Africa (Patel et al., 2020; Yangambi, 2024).

Research has consistently shown that learning environments significantly impact student motivation, attendance, and performance (Owusu & Mariwah, 2017). Poor school infrastructure—including overcrowded classrooms, inadequate ventilation, lack of sanitation, and insufficient learning materials—contributes to lower academic performance, absenteeism, and higher dropout rates (Wang et al., 2020). However, there is a lack of consensus on which infrastructure factors contribute most significantly to learning outcomes, highlighting a gap in the existing literature.

Infrastructure and Early Learning Outcomes: Wong et al. (2017) found that in early childhood education, a well-maintained and stimulating learning environment, including safe facilities and age-appropriate resources, positively impacted cognitive and social development, improving school readiness. Their study underscores the importance of investing in early childhood learning spaces, as deficiencies at this stage affect future academic success. However, their findings are limited to early education and do not explore how infrastructure influences students in higher grades or different socio-economic settings.

Infrastructure in Rural and Urban Schools: A study by Wang et al. (2020) in rural schools found that access to well-equipped libraries and computer labs had a strong positive impact on students' academic performance. Their mixed-methods approach, which included surveys, focus groups, and performance data analysis, demonstrated that students with access to these resources performed significantly better than those in schools lacking such facilities. However, the study did not extend to urban areas, making it unclear whether the same infrastructure elements hold equal importance in different regions. This gap is crucial in the context of Cameroon, where both rural and urban schools face unique infrastructure challenges**.**

2.2.2. Infrastructure Inequality and Education Gaps

Inequality in infrastructure distribution has been identified as a major factor contributing to disparities in academic performance (Agyei et al., 2024). Using ANOVA and System Generalized Method of Moments (GMM) regression, their study in Ghana revealed that districts with better infrastructure reported significantly higher student achievement levels. Importantly, they found a U-shaped relationship between class size and performance, meaning that both excessively small and excessively large classes negatively impact learning. This finding suggests that infrastructure investments should focus not just on expansion but also on optimizing class sizes for effective learning.

The Case for Cameroon: In Cameroon, infrastructure inequality is stark, with some schools operating under severely overcrowded and resource-constrained conditions (MINEDUB, 2022). Despite government efforts to increase school enrollment, completion rates remain low, suggesting that merely increasing student intake without improving infrastructure may not yield significant gains in learning outcomes. Studies have yet to fully examine how infrastructure disparities across different regions in Cameroon contribute to educational performance, which this study aims to address.

2.2.3. Inclusive School Infrastructure and Learning Outcomes

Inclusive school environments have been linked to higher engagement and academic success, particularly for students with disabilities (Cornell, 2010; Land, 2013). Land (2013) emphasized that classroom infrastructure should be designed to facilitate interaction among all students, including those with disabilities, promoting collaborative learning and social integration. Their findings suggest that modern, inclusive learning spaces contribute to better educational experiences for all students, not just those with disabilities.

However, there is limited research on how inclusive infrastructure affects academic outcomes in developing countries, where specialized facilities for disabled students remain scarce. Additionally, studies have not fully

explored whether the benefits of inclusive school design extend to students in standard learning conditions. Given Cameroon's linguistic and socio-cultural diversity, this study seeks to determine whether inclusive infrastructure has a measurable impact on overall student performance.

2.2.4. The Role of Digital Infrastructure in Education

The increasing integration of technology in education has raised questions about the impact of digital infrastructure on academic performance. Chen et al. (2019) examined the effects of technology access in low-income schools and found that students in schools with limited digital resources had lower academic achievement. They attributed this disparity to the digital divide, where students with greater access to computers and internet connectivity performed better due to their ability to engage with modern learning methods.

However, the present study contradicts these findings, revealing a negative relationship between WiFi availability and academic performance in Cameroonian schools. While research has shown that excessive internet use can lead to distractions and lower student engagement (Kasigo et al., 2017; Nehmood & Taswir, 2013), there is limited evidence linking WiFi availability in schools to decreased academic success. This unexpected finding warrants further investigation into how technology use is regulated within Cameroonian schools and whether WiFi access is being misused rather than utilized for educational purposes.

2.2.5. Unexpected Relationships Between Infrastructure and Academic Performance

Most research supports a positive correlation between infrastructure quality and student achievement. However, this study uncovered three unexpected negative relationships that require further analysis:

WiFi and Academic Performance: While some researchers have found that unregulated internet access can lead to distractions and lower academic focus, there is little empirical evidence suggesting that WiFi availability in schools directly leads to poorer student outcomes (Legg & Jon, 2024). This raises the question: Are students misusing internet resources, or is WiFi access being poorly integrated into the learning process?

Canteen Services and Academic Performance: The relationship between school meal programs and learning outcomes has been widely studied, with most findings indicating a positive impact on student health, attendance, and cognitive function (UNICEF, 2018). However, this study found a negative correlation between canteen services and student performance, contradicting existing research. Possible explanations include poor meal quality, inadequate scheduling of meal breaks, or social distractions during canteen hours.

Catch-Up Lessons and Academic Performance: While remedial education programs are generally intended to support struggling students, this study found a negative relationship between catch-up lessons and student achievement. One potential explanation is that such programs may be poorly structured, overburdening students rather than reinforcing their learning. However, little prior research has explored this issue, making it an important area for further study.

These findings highlight the need to reassess how school infrastructure and supplementary learning programs are implemented in Cameroon. Unlike previous studies that assume infrastructure investments automatically improve academic outcomes, this research suggests that context-specific factors may lead to counterintuitive results.

3. Methodology

3.1. Scope of the Study, Nature, and Source of Data

The scope of this study is limited to school infrastructure and its impact on the academic performance of pupils in Cameroonian primary schools. Given Cameroon's unique socio-economic and educational landscape, this study seeks to explore how variations in school infrastructure contribute to differences in academic achievement. To achieve this objective, the study utilizes secondary cross-sectional data obtained from the Programme d'Analyse des Systèmes Educatifs de la CONFEMEN surveys (PASEC, 2016).

PASEC is an initiative of the Conference of Ministers of Education in Francophone Africa (CONFEMEN), which has been committed to improving educational services and professional training since 1960 (PASEC, 1998). In pursuit of this objective, CONFEMEN administers the PASEC survey, a large-scale data collection initiative aimed at assessing the efficiency of educational systems within its member states. The data used in this study are sourced from the PASEC survey conducted across 10 Francophone African countries in 2014, with the findings published in 2017 (PASEC, 2017).

The PASEC survey methodology is structured to ensure representative sampling. Information was collected from pupils in grade 6, who were at the final stage of their primary school curriculum. Furthermore, data collection extended beyond pupils to include parents, teachers, and head teachers, providing insights into pedagogical resources, school infrastructure, welfare conditions, and socio-economic status. Notably, reading and numeracy test scores were collected to measure academic performance. The 2014 PASEC survey methodology employed a stratified sampling approach, wherein schools were randomly selected first, followed by a random selection of grade 6 pupils within each school. Consequently, the survey covered 31,213 pupils from 671 schools across Cameroon, ensuring a broad and representative dataset.

Moreover, data collection was not limited to terminal primary school pupils (class 6) but also included early primary school learners (class 2), thereby enabling an assessment of academic performance at different educational stages. The data encompass 180 primary schools across Cameroon's 10 regions, providing comprehensive coverage of regional disparities in infrastructure and student achievement. Findings from PASEC analyses have contributed to numerous national and international reports evaluating the education systems of Cameroon and other Francophone African countries.

To assess the impact of school infrastructure on academic performance, an infrastructure index was developed using Multiple Correspondence Analysis (MCA). This method was deemed appropriate given the binary nature of the infrastructure variables. The infrastructure index was constructed using the following components: a separate office for the headmaster, a secretariat, a storage room for school materials, a staffroom, a recreation ground, a school fence, a first aid box, an infirmary, lodging facilities for the headmaster and/or teachers, potable water, alternative water sources (such as wells), electricity, a well-equipped and functional library, a computer lab, a multimedia center, a photocopy machine, computers, internet connection, a television, a projector and DVD reader, latrines, and flushing toilets. Since all these variables are dummy variables, the MCA approach enables a more precise categorization of school infrastructure quality.

Similarly, control variables were incorporated to enhance the robustness of the analysis. These control variables were selected based on existing literature and their correlation with the school infrastructure index. They include: electricity at home, the presence of a language guide, whether the mother or father is a teacher, access to a mathematics guide, availability of a school canteen, participation in catch-up lessons, ownership of a computer at home, access to a WiFi connection, possession of a mobile phone, availability of a reading table, and access to flushing toilets. Since these control variables are also binary, they provide a structured way of capturing variations in the home and school learning environment.

In terms of research design, this study adopts an ex-post facto and causal research design. The ex-post facto approach is particularly suitable because the independent variable (school infrastructure) has already occurred, and its effects on the dependent variable (academic performance) are analyzed retrospectively. Furthermore, the causal research design allows the study to identify patterns and infer potential causal relationships between infrastructure quality and student achievement. However, while this approach facilitates hypothesis testing, it does not establish definitive causation, given the reliance on observational data rather than experimental intervention.

Therefore, by leveraging large-scale, representative survey data and employing robust statistical methods, this study aims to provide empirical insights into how school infrastructure influences academic performance. The findings are expected to guide policy decisions, inform educational investments, and contribute to broader discussions on education quality in developing countries. Moreover, the study addresses critical gaps in the literature by offering a context-specific analysis of Cameroon, a country where school infrastructure disparities are significant and under-researched.

3.2. Model Estimation

Astin's Theory of Involvement posits that students' academic performance is influenced by a combination of individual student-specific inputs and environmental attributes. According to Astin (1997), these factors include basic demographics, motivation, interest, learning styles, and previous academic attributes, along with institutional environment, home environment, and peer relations. Furthermore, the interaction between these student-specific and environmental elements plays a crucial role in shaping educational outcomes. Based on this theoretical framework, the relationship between academic performance and school infrastructure is specified through the following functional model:

$$AP = \beta_0 + \beta_1 SI_i + \beta_{2i} X_i + \mathcal{E}_i \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (1)$$

where:

- AP represents academic performance, measured through scores in mathematics and language as proxies.
- SI denotes the school infrastructure index, capturing the quality and availability of educational facilities.
- X is a vector of control variables, including factors such as electricity at home, parental education (mother and father being teachers), access to mathematics and language guides, availability of a school canteen, participation in catch-up lessons, ownership of a home computer, access to WiFi at home, possession of a mobile phone, presence of a reading table, and access to flushing toilets.
- i illustrates the cross-sectional structure of the study, representing individual pupils.
- β_0 is the intercept, while β_1 represents the coefficient of the school infrastructure index, indicating its effect on academic performance.

- E_i is the error term, accounting for unobserved factors that may influence academic performance in Cameroon.

3.3. Justification for Using the Ordinary Least Squares (OLS) Model

The Ordinary Least Squares (OLS) regression model is employed in this study to examine the relationship between school infrastructure and academic performance. This model is particularly suitable for analyzing how changes in independent variables, such as the school infrastructure index, impact the dependent variable, academic performance (Runyi & Nwakuya, 2022).

OLS provides several advantages in econometric modeling. Firstly, it assumes a linear relationship between variables, enabling straightforward predictions and an intuitive interpretation of coefficients. Secondly, it exhibits desirable statistical properties, particularly when the key assumptions of linearity, independence of errors, and homoscedasticity are met. Under these conditions, OLS estimators are unbiased, consistent, and efficient, meaning they provide reliable and valid estimates of the coefficients (Runyi & Nwakuya, 2022).

Moreover, OLS regression allows for the inclusion of control variables, which helps isolate the effect of the primary independent variable of interest (school infrastructure index) on academic performance. This approach enhances the explanatory power of the model and provides a more nuanced understanding of the multiple factors influencing student outcomes. Additionally, the incorporation of robust standard errors in the OLS framework helps address potential issues of heteroscedasticity, ensuring that statistical inferences remain valid even if the variance of the error term is not constant (Runyi & Nwakuya, 2022).

However, despite its advantages, OLS regression has notable limitations. One major weakness is endogeneity, which arises due to omitted variable bias, measurement errors, or simultaneity issues, potentially leading to biased estimates. Additionally, OLS is sensitive to outliers, leverage points, and influential observations, which may distort coefficient estimates and reduce model accuracy. Another critical limitation is its strict assumptions, such as linearity, independence, homoscedasticity, normality of residuals, and no multicollinearity. If these assumptions are violated, the results may be misleading or less reliable.

Despite these challenges, OLS remains a widely used and valuable statistical tool for analyzing the impact of various determinants on academic performance. Its interpretability, robustness, and flexibility make it particularly suitable for this study, allowing for an empirical assessment of the role of school infrastructure in shaping educational outcomes in Cameroon.

Table 1: Variables Used to Construct Infrastructure Index

Variables	Questionnaire Response Category	Frequency
A separate office for the headmaster/headmistress	Yes	2537
	No	1226
A secretariat	Yes	956
	No	2767
A packing store for school material	Yes	1315
	No	2451
Staff room	Yes	557
	No	3184
A Playground or more	Yes	3351
	No	427
School fence	Yes	976
	No	2779
A first-aid box	Yes	2676
	No	1083
Infirmary	Yes	248
	No	3477
Lodging facilities for headmaster only or including teachers	Yes	447
	No	3311
Portable water	Yes	1550
	No	2189
Other water sources	Yes	1189
	No	2526
Electricity	Yes	1309
	No	2474
An equipped and functional library	Yes	533
	No	3200
A computer lab	Yes	464
	No	3319
Internet connections	Yes	177
	No	3567
Television	Yes	375

Variables	Questionnaire Response Category	Frequency
Projector and DVD reader	No	3369
	Yes	371
Latrines	No	3373
	Yes	2878
Flushing toilets	No	902
	Yes	527
	No	3226

Source: Constructed by author using 2014 PASEC grade 6 data.

Table 2: Control Variables

Variables	Category	Frequency
Electricity at Home	Yes	2,239
	No	1,578
Mother a teacher	Yes	2,499
	No	1,318
Father a teacher	Yes	2,690
	No	1,127
Language guide	Yes	70.06
	No	29.94
Maths guide	Yes	2,233
	No	1,584
Canteen	Yes	23
	No	3,794
Catchup lessons	Yes	430
	No	3,387
Home computer	Yes	984
	No	2,833
WIFI channel	Yes	792
	No	3,025
Mobile Phone	Yes	2,730
	No	1,087
Reading table	Yes	3,318
	No	499
Flushing toilets	Yes	1,048
	No	2,769

Source: Constructed by author using 2014 PASEC grade 6 data

The variables used in constructing the school infrastructure index and those selected as control variables are dummy variables, as seen in Tables 1 and 2 above.

4. Findings

4.1. Demographic Characteristics of Respondents

The distribution of pupils in terms of age is shown on the bar chart below.

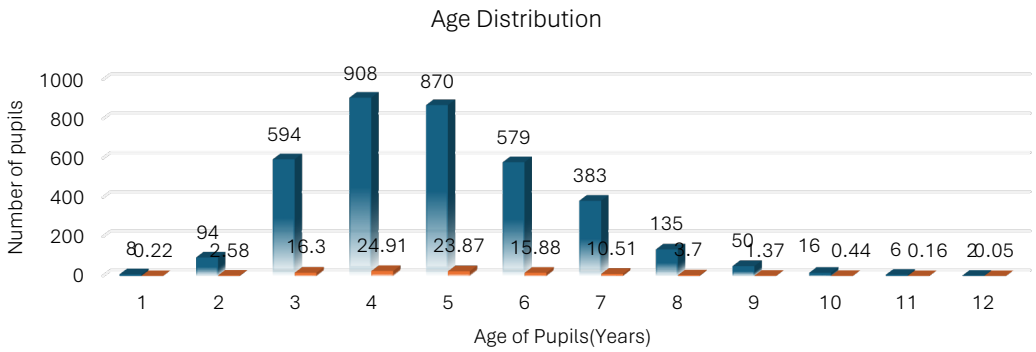

Figure 1: Age Distribution of Pupils. Source: Constructed by author using 2014 PASEC grade 6 data

The demographic characteristics of the respondents provide important insights into the composition of the study sample. As presented in Figure 1, the age of the pupils ranges from 1 to 12 years. The largest proportion of pupils are 4 years old, followed by those aged 5 years. This is followed by pupils aged 3 and 6 years, while those aged 7, 8, 2, 9, 10, 11, and 1 year constitute progressively smaller proportions. The smallest group comprises 12-year-olds, who represent the minority in the sample. The inclusion of pupils across various age groups indicates that the sample is diverse and representative, allowing the study's findings to contribute meaningfully to policy discussions on the relationship between school infrastructure and academic performance in Cameroon.

Table 3: Summary Descriptive Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
Log of performance score	3817	6.211093	0.189743	5.406109	6.688428
Performance score	3817	507.1504	94.46756	222.7632	803.0587
Infrastructure index	3817	50.85259	12.10946	23.13059	86.61953
Electricity at home	3817	0.586586	0.49251	0	1
Mother a teacher	3817	0.654703	0.475527	0	1
Father a teacher	3817	0.704742	0.456218	0	1
Language Guide	3817	0.70055	0.458077	0	1
Maths Guide	3817	0.585014	0.492784	0	1
Canteen	3817	0.006026	0.077401	0	1
Catch-up lessons	3817	0.112654	0.316211	0	1
Home computer	3817	0.257794	0.437477	0	1
WIFI Channel	3817	0.207493	0.405565	0	1
Mobile Phone	3817	0.715221	0.451368	0	1
Reading table	3817	0.869269	0.33715	0	1
Flushing toilets	3817	0.274561	0.446351	0	1

Source: Constructed by authors using 2014 PASEC grade 6 data

The descriptive statistics summary presented in Table 3 indicates that the average academic performance score of the pupils is 6.211 percent, with a standard deviation of 0.189 percent. The average school infrastructure index stands at 50.852, with a deviation of 12.109 from the mean score. The percentage distribution of pupils with access to educational and household resources is as follows: electricity at home (58.658%), mother being a teacher (65.470%), father being a teacher (70.474%), access to a language guide (70.055%), access to a Math guide (58.501%), visits to the canteen (0.06026%), participation in catch-up lessons (11.265%), access to a home computer (25.779%), availability of a WiFi channel (20.749%), ownership of a mobile phone (71.522%), possession of a reading table (86.9269%), and access to a flushing toilet facility (27.456%). These statistics suggest that a considerable proportion of pupils have access to key resources, such as electricity, parental involvement in education, study guides, and learning tools. However, access to certain resources, such as WiFi, home computers, and catch-up lessons, remains limited, which may contribute to disparities in academic performance.

Table 4: Pair Wise Correlation Matrix

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
Infrastructure Index(1)	1.0000												
Electricity at home (2)	0.3187	1.0000											
Mother a teacher (3)	0.1753	0.2866	1.0000										
Father a teacher (4)	0.0719	0.2205	0.4890	1.0000									
Language guide (5)	0.1953	0.1864	0.1700	0.1235	1.0000								
Maths guide (6)	0.2968	0.2064	0.1622	0.0994	0.5313	1.0000							
Canteen (7)	-0.0731	-0.0721	-0.0503	-0.0312	-0.0452	-0.0169	1.0000						
Catchup lessons (8)	0.0486	-0.0273	-0.0044	-0.0310	0.0520	0.0377	-0.0277	1.0000					
Home computer (9)	0.3727	0.2868	0.1849	0.1202	0.1839	0.2545	-0.0459	0.0098	1.0000				
WIFI channel (10)	0.1125	0.1593	0.1447	0.1357	0.0919	0.1110	-0.0231	0.0016	0.1829	1.0000			
Mobile phone (11)	0.0227	0.1811	0.1913	0.2126	0.1413	0.1048	-0.0034	0.0376	0.1171	0.0666	1.0000		
Reading table (12)	0.1675	0.3057	0.3264	0.2822	0.2572	0.2333	-0.0803	0.0669	0.1681	0.1084	0.2753	1.0000	
Flushing toilets (13)	0.3450	0.2506	0.1344	0.0700	0.1882	0.2382	-0.0403	-0.0094	0.4212	0.1586	0.0864	0.1550	1.0000

Source: Constructed by authors with 2014 PASEC grade 6 data using STATA

The findings presented in Table 4 provide the pairwise correlation matrix for multicollinearity assessment. The results indicate a weak relationship among the explanatory variables, as most correlation coefficients are below 0.5. Furthermore, the leading diagonal values stand at 1.000, showing that each explanatory variable is perfectly collinear with itself, as expected. Since all correlation coefficients remain below 0.75, this confirms that multicollinearity is not a concern among the explanatory variables, thereby ensuring the validity of the regression analysis.

The findings from Table 5, which presents the Ordinary Least Squares (OLS) regression results, reveal that school infrastructure and control variables account for 33.7% of the variations in pupils' academic performance in Cameroon. A 0.527 unit increase in school infrastructure is positively associated with academic performance, suggesting that infrastructure improvements significantly enhance student outcomes. This finding aligns with existing literature that underscores the importance of school infrastructure in determining educational success.

Table 5: Robust Ordinary Least Square

Variables	(1) Lperformance_score	(2) Lperformance_score (Robust Standard Errors)
Indice_Infrastructures	0.00527***	0.00527***
	(0.000240)	(0.000259)
Electricity at home	0.0712***	0.0712***
	(0.00582)	(0.00599)
Mother a teacher	0.0185***	0.0185***

Variables	(1) Lperformance_score	(2) Lperformance_score (Robust Standard Errors)
	(0.00634)	(0.00662)
Father a teacher	0.0220***	0.0220***
	(0.00644)	(0.00675)
Language guide	0.0142**	0.0142**
	(0.00658)	(0.00669)
Maths guide	0.0125**	0.0125**
	(0.00626)	(0.00632)
Canteen	-0.108***	-0.108***
	(0.0326)	(0.0261)
Catch-up lessons	-0.0320***	-0.0320***
	(0.00799)	(0.00810)
Home computer	0.0449***	0.0449***
	(0.00672)	(0.00679)
WIFI channel	-0.0168***	-0.0168***
	(0.00639)	(0.00641)
Mobile phone	0.0268***	0.0268***
	(0.00590)	(0.00595)
Reading table	0.0212**	0.0212**
	(0.00851)	(0.00906)
Flushing toilets	0.0165**	0.0165***
	(0.00644)	(0.00632)
Constant	5.811***	5.811***
	(0.0131)	(0.0135)
Observations	3,817	3,817
R-squared	0.337	0.337

Source: Constructed by authors with 2014 PASEC grade 6 data using STATA. Robust/Standard errors in parentheses*** p<0.01, ** p<0.05, * p<0.1

Moreover, the control variables exhibit both expected and unexpected relationships with academic performance. Electricity access at home is positively and significantly related to pupils' academic performance, with a coefficient of 0.0712, indicating that pupils with electricity at home score 7.12 points higher than those without access. Similarly, pupils with home computers (4.49) and electricity access (7.12) experience significant performance improvements.

Parental involvement also emerges as a significant determinant of academic performance. Pupils whose mothers are teachers score 1.85 points higher, while those whose fathers are teachers score 2.2 points higher than their counterparts. Additionally, access to mathematics guides (1.42 points), language guides (1.25 points), mobile phones (2.68 points), reading tables (2.12 points), and flushing toilets (1.65 points) all exhibit significant positive relationships with academic performance.

Unexpectedly, the study finds negative relationships between WiFi access at home (-1.68 points), visiting the canteen (-10.8 points), and participating in catch-up lessons (-3.2 points), suggesting that these factors may adversely impact academic outcomes.

5. Discussion

The findings of this study reinforce the critical role of school infrastructure in academic performance, aligning with Smith's (2018) study, which found a strong positive correlation between infrastructure and standardized test scores, and Patel et al.'s (2020) research, which established a significant link between infrastructure quality and student outcomes. These results highlight the importance of investing in educational infrastructure to enhance learning environments and improve academic achievement.

The positive influence of electricity access at home on academic performance aligns with Chen et al.'s (2019) study, which highlights the digital divide's impact on student achievement. The results indicate that technological access, such as home computers and electricity, significantly enhances learning outcomes. Additionally, the findings confirm the role of parental involvement in education, as emphasized by Topor et al. (2010) and Alma (2022), who assert that parental engagement positively influences student performance by fostering better study habits and motivation.

Moreover, the results support Comunian et al. (2020), Liao et al. (2019), and Gentili et al. (2020), who argue that parental involvement in a child's education contributes to better academic performance by facilitating communication with teachers, improving students' self-confidence, and enhancing study effectiveness.

However, some unexpected findings raise important concerns. The negative relationship between WiFi access and academic performance contradicts previous research that emphasizes the positive role of technology in education. This result suggests that WiFi access may lead to digital distractions, as supported by Dhiman (2021), Silas & Mwila (2024), and Legg & Jon (2024), who argue that excessive and unregulated technology use can reduce self-control and discipline, leading to lower academic engagement.

Additionally, the negative impact of school canteen visits on academic performance is consistent with Dorji et al. (2021) and Kristy et al. (2023), who found that poor nutritional quality in school canteens can hinder concentration and learning capacity. Furthermore, Miora et al. (2024), using PASEC data from Madagascar, demonstrated that school canteen programs had limited effects on student learning outcomes, highlighting the importance of monitoring the nutritional quality of meals provided in schools.

The negative relationship between catch-up lessons and academic performance presents an interesting paradox. While repetition and reinforcement are generally beneficial to learning, as argued by Barrie (2023), the effectiveness of catch-up lessons may depend on how they are implemented. According to Chanda (2024), factors such as overcrowded classrooms, inadequate teacher training, and logistical barriers may reduce the effectiveness of remedial education programs.

Overall, these findings align with Awudu (2014), who established a positive relationship between school infrastructure and pupil performance, as well as Land (2013) and Cornell (2010), who emphasize the importance of inclusive infrastructure in ensuring that all students, regardless of background, benefit from educational investments. Furthermore, Yang et al. (2019) highlight the importance of culturally relevant infrastructure, which may be an important consideration for Cameroon's diverse educational landscape.

These results offer valuable insights for policymakers, suggesting that investment in school infrastructure should be complemented by measures to regulate technology use, improve nutritional standards in school canteens, and ensure the effectiveness of catch-up lessons. Addressing these issues holistically will enhance educational outcomes and reduce disparities in access to quality learning environments.

Moreover, the results of this study align with the Human Capital Theory (Coleman,1988), which posits that investments in education contribute to individual and societal productivity. School infrastructure plays a fundamental role in the accumulation of human capital, as access to proper educational facilities fosters learning and skill development. Additionally, the findings support the Education Production Function model (Hanushek & Woessmann, 2007), which suggests that variations in school inputs, including classroom conditions and availability of resources, directly affect academic performance. The study also provides insights into the role of social capital in education (Coleman, 1988), as pupils with parental support—such as having parents who are teachers—tend to perform better academically. The negative impact of WiFi access on performance may be explained through Astin's Theory of Involvement (Astin, 1997), which suggests that external distractions reduce students' engagement and learning efficiency. These theoretical perspectives provide a comprehensive framework for interpreting the study's findings and highlight the importance of infrastructure investment in shaping educational outcomes in Cameroon.

6. Conclusions and Policy Implications

Based on the findings of this study, it can be concluded that school infrastructure plays a significant role in shaping pupils' academic performance in Cameroon. The quality of infrastructure, including classroom conditions, resources, and accessibility, affects the learning environment and, subsequently, pupils' educational outcomes. However, the results of this study indicate that measures to address infrastructure deficiencies in Cameroon must begin with the most basic facilities, such as classrooms, desks, libraries, chalkboards, benches, and other essential educational materials. The negative relationship observed between WiFi access and academic performance suggests that most Cameroonian pupils are not yet equipped to manage the distractions associated with advanced infrastructure linked to Internet connectivity. Furthermore, inclusive education remains an essential component of the Cameroonian education system. School infrastructure must be designed and adapted to accommodate the diverse needs of all pupils, including those with disabilities. Failure to address infrastructure-related barriers to inclusion may result in unequal educational opportunities and hinder the overall quality of education.

From a policy perspective, the Cameroonian government and relevant stakeholders should prioritize investments in school infrastructure, focusing on classroom construction, the provision of teaching materials, and the maintenance of facilities. Additionally, training and professional development programs for teachers should be established to promote inclusive classroom environments that cater to the diverse needs of pupils, including those with disabilities. Mechanisms for the regular maintenance and upkeep of school infrastructure should also be put in place to ensure that facilities remain conducive to learning. Furthermore, the involvement of parents, communities, and other stakeholders in the improvement and maintenance of school infrastructure is essential to fostering a sense of ownership and responsibility.

A further examination of ownership and responsibility requires that the government address urban-rural disparities by strengthening the implementation of decentralization policies to ensure that local government authorities are fully engaged in managing key social infrastructure such as schools. By actively involving local authorities, who maintain direct contact with academic institutions, resource allocation for school infrastructure development can be more efficiently managed. Addressing school infrastructure issues in Cameroon is crucial for improving the quality of education and fostering inclusive practices. By implementing the proposed recommendations, Cameroon can create a more conducive learning environment that supports the academic success of all pupils. Given the similarities between Cameroon and other sub-Saharan African countries, particularly those in Francophone Africa, the findings of this study may also be applicable to these regions.

Future research could replicate this study using similar data from another CONFEMEN country to generate findings relevant to that context.

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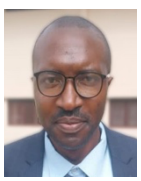

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