



Ergonomic Factors Associated with School Performance: The Mediating Role of Motivation among Primary School Students

M. Cayllahue-Huaman^{*1}, A. Benavente-Suyo¹,
R. Falcon-Soncco¹ L.M. Oliart-Murillo¹, R.E. Morales-Fano¹ and
O. Gutierrez Aguilar¹

¹ Universidad Nacional de San Agustín de Arequipa, Perú
mcayllahueh@unsa.edu.pe, abenaventess@unsa.edu.pe,
rfalcons@unsa.edu.pe, loliart@unsa.edu.pe, rmralesf@unsa.edu.pe,
ogutierrez@unsa.edu.pe

Abstract. This study examined the relationships between ergonomic and technological classroom conditions, motivation, and school performance among primary school students. It also assessed whether motivation mediated the relationships between accessibility to technological resources, workspace conditions, noise, temperature, and school performance. The research was conducted in four primary schools in Arequipa, Peru, including two public and two private institutions. After data-quality screening, the final sample consisted of 211 students. A quantitative, non-experimental, cross-sectional design was employed, and the proposed relationships were evaluated using partial least squares structural equation modeling. Accessibility of Technological Resources and my Workspace were positively associated with motivation, while motivation was positively associated with School Performance. Neither Noise nor Temperature showed statistically significant direct relationships with Motivation or School Performance. The mediation analysis indicated significant indirect relationships between Accessibility of Technological Resources and School Performance through Motivation, and between my Workspace and School Performance through Motivation. No significant indirect effects were found for Noise or Temperature. These findings suggest that motivation is a relevant psychological mechanism connecting perceived technological accessibility and workspace adequacy with school performance. Because the study was cross-sectional and non-experimental, the findings should be interpreted as associations rather than causal effect.

Keywords: My Workspace, Noise, Temperature, Accessibility of Technological Resources, Motivation, School Performance.

1 Introduction

Educational infrastructure remains a critical challenge for improving learning conditions in Peru, particularly in contexts where schools face limitations in physical environments, technological access, and classroom maintenance. These deficiencies are more evident in vulnerable and rural areas, where inadequate school facilities and limited access to internet connectivity or digital devices restrict opportunities for equitable and quality education [1-3]. Although the COVID-19 pandemic intensified attention to digital gaps and emergency remote education, these problems also affect face-to-face schooling, since students' learning experiences depend not only on pedagogical practices but also on the physical and technological conditions of the classroom [4,5].

In this context, classroom ergonomics becomes relevant because learning environments should provide conditions that promote comfort, concentration, safety, motivation, and academic engagement. Ergonomic factors such as the quality of the workspace, noise, temperature, lighting, furniture, and access to technological resources can influence students' well-being and learning processes. Previous studies have shown that poor ergonomic conditions may generate fatigue, discomfort, stress, or reduced concentration, affecting students' motivation and school performance [6,7]. Similarly, access to technological resources may support autonomy, interaction, flexibility, and student engagement when these resources are available and pedagogically integrated [8,9].

However, the relationship between ergonomic conditions, technological access, motivation, and school performance has not been sufficiently examined in primary education, especially in the Peruvian school context. Much of the existing literature has focused on virtual or higher education environments, while fewer studies have analyzed how these factors operate in regular face-to-face classrooms with children. This generates a conceptual and empirical gap: although technology, workspace, noise, and temperature are frequently associated with learning outcomes, it remains unclear whether their effect on school performance occurs directly or through students' motivation. This distinction is important because motivation has been identified as a key predictor of academic achievement and learning persistence [10-12].

The present study addresses this gap by analyzing ergonomic and technological factors in primary school classrooms and estimating their direct and indirect relationships with school performance through motivation. Unlike studies focused only on digital learning environments, this research examines access to technological resources as one component of the broader classroom learning environment, together with workspace conditions, noise, and temperature. Therefore, the central research question is: How do ergonomic and technological factors relate to school performance, and what mediating role does motivation play in this relationship among primary school students?

Based on the reviewed literature, the proposed hypotheses were organized into two levels. The direct-effect hypotheses were considered secondary hypotheses because they examine the individual relationships required to understand the structural mechanism. The mediation hypotheses were considered the primary hypotheses because

they directly address the central purpose of the study: determining whether motivation transmits the relationships between classroom ergonomic conditions and school performance.

Secondary hypotheses: direct effects

H1: Accessibility of Technological Resources is positively associated with Motivation.

H2: Accessibility of Technological Resources is positively associated with School Performance.

H3: Motivation is positively associated with School Performance.

H4: My Workspace is positively associated with Motivation.

H5: My Workspace is positively associated with School Performance.

H6: Noise is negatively associated with Motivation.

H7: Noise is negatively associated with School Performance.

H8: Temperature is associated with Motivation.

H9: Temperature is associated with School Performance.

Primary hypotheses: mediation effects

H10: Motivation mediates the relationship between Accessibility of Technological Resources and School Performance.

H11: Motivation mediates the relationship between My Workspace and School Performance.

H12: Motivation mediates the relationship between Noise and School Performance.

H13: Motivation mediates the relationship between Temperature and School Performance.

This organization distinguishes individual structural relationships from the main explanatory mechanism examined in the study, facilitating a more direct assessment of the proposed hypotheses.

2 Methodology

The research adopted an explanatory quantitative approach using a non-experimental, cross-sectional design. The initial database comprised 260 completed questionnaires. Before estimating the measurement and structural models, the data were checked for missing values, responses outside the permitted range, and consistent response patterns. A criterion was established whereby a variance greater than 0.025 was accepted; consequently, questionnaires with values below this threshold were excluded. Based on this data quality criterion, 49 questionnaires were excluded because they exhibited insufficient variation across instrument items. These responses did not provide sufficient variability to distinguish students' perceptions across the six constructs and could have affected the estimation of variances, correlations, and structural relationships.

The exclusion procedure was carried out prior to testing the hypotheses and was based exclusively on data quality considerations, not on the direction, magnitude, or statistical significance of the results. Following completion of the selection process,

211 valid questionnaires were retained for the measurement and structural model analyses.

The final sample included 43% male students ($N = 91$) and 57% female students ($N = 120$), with ages ranging from 8 to 13 years ($M = 10.60$; $SD = 1.19$). Data were collected between November and December 2024 via a survey administered after instructions for proper completion were provided. Because the participants were minors, prior authorization was obtained from the educational institutions involved in the study. The sample was drawn from four primary schools: two public schools, representing 68% of the final sample ($N = 144$), and two private schools, representing 32% ($N = 67$).

The instrument was adapted from the study by Gumasing and Castro [1]; the original instrument was developed to evaluate ergonomic conditions during online classes. Therefore, references exclusively associated with online learning and home-based virtual classes were reformulated to describe regular classroom and schoolwork conditions. The wording was also simplified to facilitate comprehension for primary school students aged 8 to 13. The adaptation preserved the conceptual meaning of the original dimensions: technological accessibility, workspace conditions, noise, temperature, motivation, and school performance.

No formal expert-based content validation procedure or independent pilot test was conducted prior to the main application. Consequently, the evidence regarding the scale's contextual adaptation is based primarily on measurement model results from the final sample. This limitation should be considered when interpreting the findings, and future studies should conduct expert validation, cognitive interviews with children, and pilot testing before replicating the instrument in other primary school settings.

The final instrument measured six latent variables: 'My workspace' (MES; 5 items), 'Noise' (RUI; 3 selected items), 'Temperature' (TEM; 4 items), 'Access to technological resources' (ART; 3 selected items), 'Motivation' (MOT; 5 items) and 'School performance' (RE; 5 items). Responses were recorded on a five-point Likert scale ranging from 1 = 'strongly disagree' to 5 = 'strongly agree'. Data processing and analysis were conducted using Jamovi v.2.6.13.0 and SmartPLS v.4.1.0.9. Variance-based structural equation modeling (PLS-SEM) was applied to examine the relationships among the latent variables in the proposed structural model.

3 Results

Table 1 presents the factor loadings (λ), convergent validity, and reliability estimates for 211 students. The factor loadings of the items, which indicate their correlations with their respective theoretical constructs, are adequate, all above 0.700. This indicates strong and consistent associations between the items and their underlying constructs. The loadings range from 0.724 to 0.838 across several factors, including Accessibility of technological resources (ART), The workspace (MES), Motivation (MOT), School performance (RE), Temperature (TEM), and Noise (RUI). These values indicate substantial consistency in item responses within each construct.

It was decided to remove certain items from the constructs to improve model fit and clarify the relationships between the variables and their indicators. Items ART1 and ART3 of the Technological Resources Accessibility (ART) variable, and RUI1 and RUI4 of the Noise (RUI) variable were removed due to their poor performance in the factor loadings, indicating a weak correlation with their respective constructs. This removal helped to improve the internal consistency and convergent validity of the affected constructs, ensuring that the remaining items were more representative and precise in measuring the proposed theoretical aspects.

Cronbach's alpha coefficients ranged from 0.710 to 0.857. All constructs, therefore, met the commonly accepted minimum threshold of 0.70, including Noise (RUI), which obtained an alpha coefficient of 0.710. Composite reliability, assessed using rho_A and rho_C, also exceeded 0.70 for all constructs, indicating adequate internal consistency.

Regarding convergent validity, the Average Variance Extracted values ranged from 0.565 to 0.642, exceeding the recommended minimum criterion of 0.50 in all cases. my Workspace obtained an AVE of 0.565; therefore, it met the criterion for convergent validity and should not be interpreted as being below the acceptable threshold. Overall, the reliability and convergent validity results support the adequacy of the retained measurement model.

Overall, these findings support the validity and reliability of the measurement instrument used in this study on ergonomic factors influencing school performance, mediated by motivation, in primary school students. The strong psychometric properties of the constructs provide a solid basis for the subsequent analyses and conclusions of the research.

Table 1. Loadings, convergent validity, and reliability estimates.

Item	Loading	Alpha	CR (rho_a)	CR (rho_c)	AVE
ART2	0.771	0.729	0.756	0.843	0.642
ART4	0.798				
ART5	0.832				
MES1	0.784	0.807	0.812	0.866	0.565
MES2	0.724				
MES3	0.724				
MES4	0.731				
MES5	0.793				
MOT1	0.749	0.857	0.858	0.898	0.637
MOT2	0.757				
MOT3	0.852				
MOT4	0.834				
MOT5	0.795				
RE1	0.795	0.856	0.857	0.897	0.636
RE2	0.822				
RE3	0.776				

RE4	0.765				
RE5	0.826				
RUI2	0.769	0.710	0.713	0.837	0.632
RUI3	0.787				
RUI5	0.828				
TEM1	0.787	0.855	0.859	0.896	0.634
TEM2	0.754				
TEM3	0.838				
TEM4	0.761				

Figure 1 presents the structural model, including the coefficients of determination, standardized path coefficients, and p-values. School Performance (SP) obtained an R^2 value of 0.597, indicating that 59.7% of its variance was explained jointly by Motivation, Accessibility of Technological Resources, My Workspace, Noise, and Temperature. Motivation obtained an R^2 value of 0.305, indicating that the four ergonomic and technological predictors explained 30.5% of the variance in motivation.

Accessibility of Technological Resources was positively and significantly associated with Motivation ($\beta = 0.282$, $p < 0.001$). My Workspace was also positively associated with motivation ($\beta = 0.238$, $p = 0.007$). In contrast, Noise was not significantly associated with motivation ($\beta = 0.005$, $p = 0.954$), and Temperature was not significantly associated with motivation ($\beta = 0.130$, $p = 0.182$).

Motivation showed the strongest direct association with School Performance ($\beta = 0.588$, $p < 0.001$). The direct relationships between Accessibility of Technological Resources and School Performance ($\beta = 0.133$, $p = 0.129$), My Workspace and School Performance ($\beta = 0.092$, $p = 0.140$), Noise and School Performance ($\beta = 0.013$, $p = 0.827$), and Temperature and School Performance ($\beta = 0.088$, $p = 0.244$) were not statistically significant.

These results indicate that technological accessibility and workspace conditions are related primarily to students' motivation rather than directly to school performance. They also provide preliminary support for examining motivation as an indirect mechanism connecting these classroom conditions with school performance. Because the study used a cross-sectional, non-experimental design, the estimated paths represent statistical associations and should not be interpreted as causal effects.

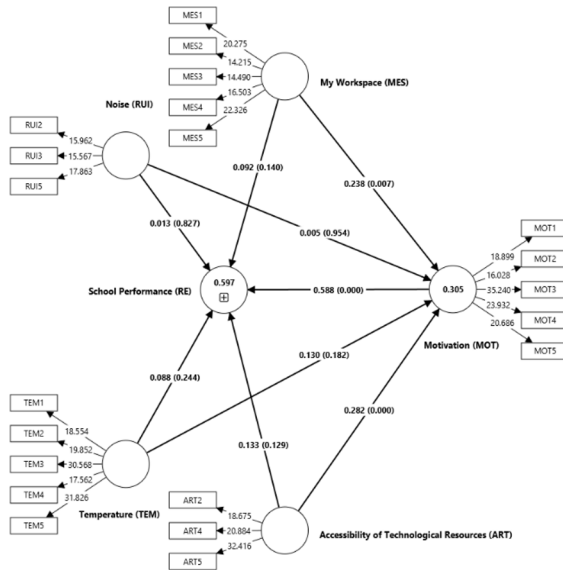


Fig. 1. R-squared (R^2) - path coefficients and p values - SmartPLS.

Table 2 presents the results of the secondary hypotheses concerning the direct relationships among the constructs. H1 was supported because Accessibility of Technological Resources was positively associated with Motivation ($\beta = 0.282$, $p < 0.001$). H2 was not supported because the direct relationship between School Performance and H2 was not statistically significant ($\beta = 0.133$, $p = 0.129$).

H3 was supported: Motivation showed a positive and statistically significant association with School Performance ($\beta = 0.588$, $p < 0.001$). H4 was also supported because my Workspace was positively associated with Motivation ($\beta = 0.238$, $p = 0.007$). However, H5 was not supported because the direct relationship between my Workspace and School Performance was not significant ($\beta = 0.092$, $p = 0.140$).

Neither of the noise-related hypotheses was supported. Noise was not significantly associated with Motivation (H6: $\beta = 0.005$, $p = 0.954$) or School Performance (H7: $\beta = 0.013$, $p = 0.827$). Similarly, Temperature was not significantly associated with Motivation (H8: $\beta = 0.130$, $p = 0.182$) or School Performance (H9: $\beta = 0.088$, $p = 0.244$).

Overall, three of the nine direct-effect hypotheses were supported: H1, H3, and H4. The findings show that technological accessibility and workspace conditions were associated with School Performance indirectly through their relationships with Motivation rather than through statistically significant direct paths.

Table 2. Path coefficient test - direct effects.

Hypothesis	β	Mean (M)	STDEV	t value	p value
H1: Accessibility of Technological Resources (ART) -> Motivation (MOT)	0.282	0.286	0.076	3.738	0.001

H2: Accessibility of Technological Resources (ART) -> School Performance (RE)	0.133	0.134	0.088	1.520	0.129
H3: Motivation (MOT) -> School Performance (RE)	0.588	0.585	0.058	10.080	0.001
H4: My Workspace (MES) -> Motivation (MOT)	0.238	0.242	0.089	2.679	0.007
H5: My Workspace (MES) -> School Performance (RE)	0.092	0.091	0.062	1.476	0.140
H6: Noise (RUI) -> Motivation (MOT)	0.005	0.002	0.081	0.058	0.954
H7: Noise (RUI) -> School Performance (RE)	0.013	0.019	0.061	0.218	0.827
H8: Temperature (TEM) -> Motivation (MOT)	0.130	0.128	0.097	1.336	0.182
H9: Temperature (TEM) -> School Performance (RE)	0.088	0.088	0.076	1.166	0.244

Table 3 presents the results of the primary mediation hypotheses. H10 was supported because Accessibility of Technological Resources showed a statistically significant indirect relationship with School Performance through Motivation ($\beta = 0.166$, $p = 0.001$). Although the direct relationship between Accessibility of Technological Resources and School Performance was not significant, its indirect relationship through Motivation was significant, indicating an indirect-only mediation pattern.

H11 was also supported. My Workspace showed a statistically significant indirect relationship with School Performance through Motivation ($\beta = 0.140$, $p = 0.011$), whereas its direct relationship with School Performance was not significant. This result also indicates an indirect-only mediation pattern.

H12 was not supported because the indirect relationship between Noise and School Performance through Motivation was not statistically significant ($\beta = 0.003$, $p = 0.954$). H13 was likewise not supported because the indirect relationship between Temperature and School Performance through Motivation did not reach statistical significance ($\beta = 0.076$, $p = 0.187$).

Therefore, two of the four primary mediation hypotheses were supported. Motivation mediated the relationships of technological accessibility and workspace conditions with School Performance, but it did not mediate the relationships involving Noise or Temperature.

Table 3. Specific indirect effects - Bootstrapping.

Hypothesis	β	Mean (M)	STDEV	t value	p value
H10: Accessibility of Technological Resources (ART) -> Motivation (MOT) -> School Performance (RE)	0.166	0.167	0.048	3.462	0.001
H11: My Workspace (MES) -> Motivation (MOT) -> School Performance (RE)	0.140	0.142	0.055	2.547	0.011
H12: Noise (RUI) -> Motivation (MOT) -> School Performance (RE)	0.003	0.001	0.048	0.057	0.954
H13: Temperature (TEM) -> Motivation (MOT) -> School Performance (RE)	0.076	0.075	0.058	1.320	0.187

4 Discussion

The study examined whether perceived classroom ergonomic and technological conditions were associated with School Performance and whether motivation functioned

as an explanatory mechanism in these relationships. The findings show that the Accessibility of Technological Resources and my Workspace were positively associated with motivation, and that motivation was strongly associated with School Performance. In contrast, neither Noise nor Temperature showed statistically significant direct or indirect relationships in the estimated model.

The positive relationship between Accessibility of Technological Resources and Motivation is consistent with research suggesting that access to digital tools can facilitate information retrieval, interaction, perceived usefulness, autonomy, and engagement in learning activities [8,9,13,14]. In the present study, technological accessibility was not directly associated with School Performance; however, its indirect relationship through motivation was statistically significant. This finding indicates that merely having access to technological resources may not be sufficient to improve school outcomes. Instead, such resources may become academically relevant when they contribute to students' willingness, interest, and engagement in learning activities.

My Workspace was also positively associated with motivation. This result supports the assumption that an organized, functional, and comfortable learning space may contribute to students' psychological disposition toward schoolwork [1,6,15]. Nevertheless, workspace conditions did not show a statistically significant direct relationship with School Performance. The significant indirect effect suggests that the relationship operates mainly through motivation. Thus, students' perceptions of an adequate workspace may be associated with better performance insofar as such conditions support concentration, persistence, and willingness to participate in academic tasks.

Motivation was the strongest direct predictor of School Performance. This result is consistent with prior literature identifying motivation as an important determinant of engagement, persistence, self-regulation, and academic achievement [10–12,18,19]. The finding also supports the theoretical role assigned to motivation in the proposed model. Rather than functioning solely as another predictor, motivation appears to link students' perceptions of classroom resources and workspace conditions to their perceived academic outcomes.

Noise was not significantly associated with either Motivation or School Performance. This finding differs from studies that describe environmental noise as a possible source of distraction, discomfort, or cognitive interference. One possible interpretation is that the noise levels experienced by the participating students were not sufficiently heterogeneous or intense to produce detectable differences. It is also possible that children had adapted to the usual auditory conditions of their classrooms. Because noise was measured through student perceptions rather than objective acoustic indicators, future research should combine questionnaires with sound-level measurements and observations conducted at different times of the school day.

Temperature also showed no statistically significant direct or indirect relationships. The absence of significance does not demonstrate that thermal conditions are irrelevant. Instead, it indicates that perceived temperature did not explain a substantial amount of variation in Motivation or School Performance in this sample. The participating schools may have had relatively similar thermal conditions, or the data-

collection period may not have captured sufficient variation. Future studies should incorporate objective measurements of classroom temperature, humidity, ventilation, and seasonal differences.

The model explained 30.5% of the variance in motivation and 59.7% of the variance in School Performance. These values suggest that the model has meaningful explanatory capacity, particularly for School Performance. Nevertheless, the cross-sectional design prevents the establishment of temporal or causal relationships. It is therefore not possible to conclude that improvements in technological accessibility or workspace conditions necessarily cause increases in motivation or performance. Longitudinal and experimental studies are required to examine the direction and stability of the observed relationships.

From a practical perspective, the findings suggest that schools should not view technological resources and physical workspace improvements as isolated infrastructure interventions. Their educational value may depend on how these resources are integrated into learning activities and whether students perceive them as useful, accessible, and supportive of their engagement. Consequently, classroom improvement strategies should combine infrastructure, technology, pedagogical guidance, and motivational support.

5 Conclusions

The study provides differentiated evidence regarding the direct and indirect hypotheses proposed in the structural model. Among the nine secondary direct-effect hypotheses, H1, H3, and H4 were supported. Accessibility of Technological Resources was positively associated with Motivation (H1), Motivation was positively associated with School Performance (H3), and My Workspace was positively associated with Motivation (H4).

The remaining direct-effect hypotheses were not supported. Accessibility of Technological Resources did not show a statistically significant direct relationship with School Performance (H2), and My Workspace was not directly associated with School Performance (H5). Noise was not significantly associated with Motivation or School Performance; therefore, H6 and H7 were not supported. Temperature was also unrelated to Motivation and School Performance at the established significance level; consequently, H8 and H9 were not supported.

Regarding the four primary mediation hypotheses, H10 and H11 were supported. Motivation significantly mediated the relationships between Accessibility of Technological Resources and School Performance, and between my Workspace and School Performance. These results indicate that technological accessibility and workspace conditions were associated with School Performance primarily through their relationship with students' Motivation.

H12 and H13 were not supported. Motivation did not mediate the relationships between Noise and School Performance, or between Temperature and School Performance. Thus, the study did not find sufficient statistical evidence that the perceived

auditory and thermal conditions evaluated in the participating schools were related to performance through Motivation.

The central conclusion is that Motivation is the primary explanatory mechanism linking perceived technological accessibility and workspace adequacy to School Performance. The results do not support the conclusion that all ergonomic conditions have equivalent educational relevance. Instead, they show that the technological and spatial dimensions were associated with Motivation, whereas Noise and Temperature were not significant within the specific conditions of the analyzed sample.

These findings should be interpreted as statistical associations rather than causal effects because the research employed a non-experimental and cross-sectional design. In addition, reliance on self-reported perceptions, the sample's concentration in four schools, and the absence of objective environmental measurements limit the generalizability of the results. Future studies should employ longitudinal or experimental designs, larger, more diverse samples, objective measurements of noise and temperature, and instruments previously validated for face-to-face primary education.

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