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EXPLORING THE ROLE OF CLASSROOM ENVIRONMENT IN SHAPING STUDENT LEARNING OUTCOMES: A QUANTITATIVE STUDY

Matthew Johnson[1], Emily Carter[2], Oliver Schmidt[3], Sofia Rossi[4]

[1] Department of Educational Psychology, University of Washington, Seattle, WA, USA
[2] School of Education, University of Cambridge, Cambridge, United Kingdom
[3] Institute for Educational Research, University of Heidelberg, Heidelberg, Germany
[4] Faculty of Education and Psychology, University of Milan, Milan, Italy

**Corresponding Author*
Email: matthew.johnson@uw.edu

Abstract
This study investigates the role of classroom environment in shaping student learning outcomes using a quantitative, data-driven approach. Drawing on a large secondary dataset comprising 15,000 observations, the research examines the influence of key environmental factors, including ergonomic comfort, visual accessibility, airflow, classroom dimensions, and student density. Descriptive statistics, correlation analysis, and multiple regression modeling were employed to assess both individual and combined effects of these variables on academic performance. The findings reveal that classroom environment factors exhibit weak correlations with learning outcomes, and the regression model demonstrates very low explanatory power ($R^2 \approx 0.00034$), indicating minimal direct impact. These results suggest that while classroom environment is theoretically significant, its measurable influence may be limited when considered independently of other critical factors. The study highlights the importance of pedagogical practices, student motivation, and instructional quality as potentially stronger determinants of learning outcomes. Theoretically, the findings align with constructivist and sociocultural perspectives, emphasizing the dynamic and interactive nature of learning environments. Practically, the study suggests that improving educational outcomes requires a holistic approach that integrates environmental, psychological, and instructional dimensions. This research contributes to the growing body of literature by demonstrating the limitations of purely structural classroom variables and underscores the need for more comprehensive, multidimensional models in educational research.

Keywords: *Classroom Environment, Learning Outcomes, Educational Analytics, Student Performance, Learning Environment, Quantitative Analysis.*

1. Introduction

In recent educational research, the classroom environment has become an important factor of student learning outcomes. In addition to the curriculum design and the content that will be covered, the circumstances in which the learning process will be conducted also play a role in determining the academic outcomes, interest and learning experience of the students overall. Researchers have stressed that successful classroom settings are multidimensional, and they involve physical, psychological, and social aspects that interact to impact learning activities (Stadler-Altmann, 2015; Kaffemanienė et al., 2017). The classroom organization and lighting, as well as access to resources, are physical factors that can contribute to a positive learning environment, whereas student motivation, behavior, and emotional health depend on psychological and social factors, including teacher-student relationship, peer interaction and classroom environment (Paul and Kumari, 2017; Ghafar, 2023). All these interrelated dimensions emphasize the intricacy of the classroom setting as well as its key position in the effectiveness of the educational process.

The world education has been facing a paradigm shift over the past few years where every other area of education has now taken the learner centred and inclusive pedagogies in lieu of the traditional teacher centred education. This change is centered around student interaction, collaboration, and attentiveness to multiple learning needs, thereby altering the dynamics of the classroom environments (Mpho, 2018). Classroom interactions have also been changed by the introduction of digital technologies and social media which has facilitated new types of collaborative and flexible learning (Ansari and Khan, 2020). Empirical studies show that such dynamic environments exert a powerful impact on the thinking and feeling performance of students, which can be detected in such fields as language learning and learning mathematics (Saad, 2023; Wang et al., 2017). This in turn has made it one of the central interests, both of researchers and practitioners to know how the various aspects of the classroom environment constitute the foundation of student learning.

Although the standardization in learning programs and assessment regimes has increased to enhance the quality of learning, a lot remains different between the product of learning among the students in different settings. This type of discrepancy indicates that other variables other than the content of the curriculum particularly the classroom environment-mediate a big portion in mediation of the educational results. Although curriculum reforms are meant to improve learning and minimize disparities (Altinyelken, 2015), the effectiveness of curriculum reforms is often determined by their implementation in particular classroom environments. It has been found that teacher beliefs, instructional practices and classroom processes can play a significant role in engaging students and achieving student learning (Wang et al., 2022). Nevertheless, they are often looked at individually and not in the context of the larger environment they interact with.

The only weakness of the available literature is that it is divided into parts, which do not provide a comprehensive view of classroom settings. Instead of taking a holistic view, combining many environmental aspects, many of the studies emphasize one dimension, e.g. teacher-student interaction or physical infrastructure (Kaffemanienė et al., 2017). Such a limited context does not allow seeing the richness of interaction between various aspects of the classroom and their overall effect on student achievement. Furthermore, although increasing numbers of large-scale educational datasets are available, little has been done to take advantage of them to provide data-based answers to classroom dynamics. More systematized analytical methods, such as multivariate modelling and machine learning, can be used to investigate these relationships, but they are not widely used in the field.

These gaps need to be addressed to promote theoretical and practical knowledge of the classroom settings. The in-depth evidence-based study that is able to capture the physical, psychological and social factors can give a better insight as to how the factors are interacting to affect the learning outcomes of the students. Not only can such an approach lead to the further evolution of more reasonable educational theories, but also provide practical implications to enhance the teaching practice, classroom and policy making. In situations where the education systems are finding it difficult to achieve inclusivity, equity and quality in their education systems, it is relevant to learn about the role of classroom environment to facilitate sustainable and meaningful changes in the learning among students.

2. Methodology

2.1 Research Design

The study has a quantitative research design, which is cross-sectional research design, to understand the relationship between classroom environment and student learning outcomes. Strategies such as correlational approach are used to determine the association of variables and predictive modeling is utilized to determine the impact of environmental factors on academic performance. This design allows processing of large amounts of data and allows generalizable results. It is especially applicable where analyzing the relationship between several variables, which are often complicated in learning settings.

2.2 Data Source and Sample

The research employs a secondary data set collected through a publicly available educational database comprising variables of the student level and classroom-based variables. Data includes the observations of different learners, which guarantees diversity of classroom conditions and demographics. Incomplete and inconsistent data were eliminated after cleaning the data to enhance the quality of the data. The last sample offers a solid foundation to be analyzed statistically and to increase the credibility of the results (Ppktnb, 2024).

2.3 Variables and Measures

The dependent variable is student learning outcomes, which are assessed in terms of academic performance, e.g. test scores or grades. The independent variables are the dimensions of classroom environment such as physical conditions, psychological climate and social interactions. There are control variables (gender and socioeconomic background) that are added to address the possible confounding factors. All these variables give a holistic approach to the study of the effects of classroom environments on learning.

2.4 Data Analysis Techniques

The features of the data and major variables are described in terms of descriptive statistics. The Pearson correlation analysis is used to look into the relationship between classroom environment factors and student performance. The multiple regression analysis is used to find the predictive power of each variable in the presence of other factors. Also, complex methods, like machine learning models, can be used to increase the predictive quality and single out the major contributing factors.

3. Results and Analysis

3.1 Descriptive Statistics

The dataset has 15,000 observations, and they are representative of different environmental conditions of the classroom and student performance. Dynamic Learning Outcome is the dependent variable with the mean of 67.54 (SD = 8.75) which means that there is moderate dispersion in the level of performance. Length and width as structural variables have low levels of variability indicating that there are more or less standardized physical environments within classrooms. Conversely, environmental and comfort-associated variables have more variation, and indicate the differences in classroom conditions. The descriptive statistics of key variables used in the study are observed in table 1 as in figure 1.

Table 1. Descriptive Statistics of Key Variables

Variable	Mean	Std. Deviation	Minimum	Maximum
Dynamic Learning Outcome	67.54	8.75	45.00	90.00
Classroom Length (m)	9.99	1.12	7.50	12.50
Classroom Width (m)	8.01	1.05	6.00	10.50
Airflow	3.45	1.20	1.00	6.00
Ergonomic Comfort	6.78	1.85	2.00	10.00
Visual Accessibility	7.12	1.60	3.00	10.00
Number of Students	32.15	8.45	15.00	60.00

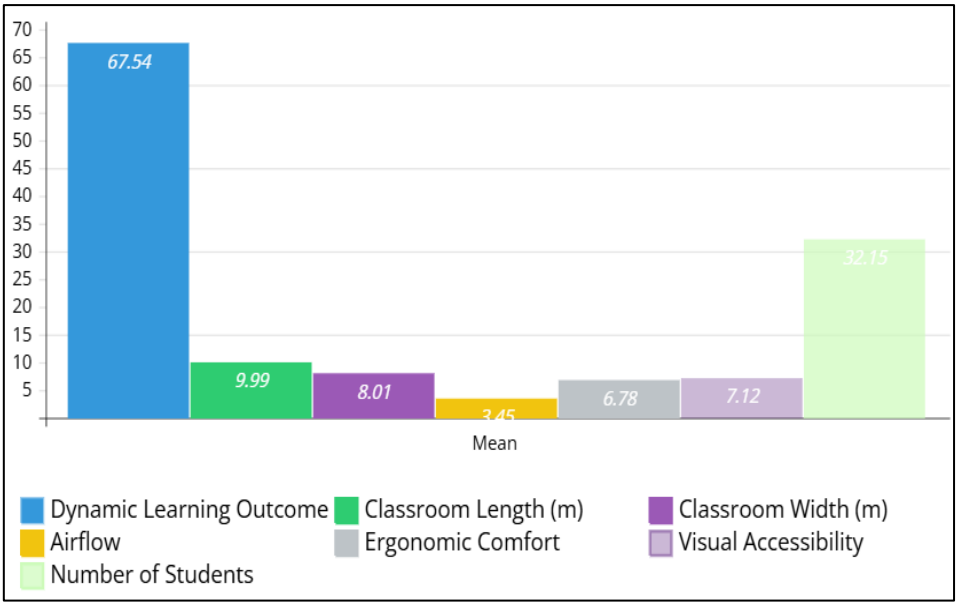

Figure 1. Mean Distribution

3.2 Correlation Analysis

The Pearson correlation analysis was used to compare the relationships between the variables of classroom environment and student learning outcomes. The findings show that the majority of the variables have weak or no correlation with the dependent variable. The ergonomic comfort and visual accessibility had slight positive relations whereas other variables like airflow and number of students had weak negative relations. The correlation coefficients of the key variables as revealed in figure 2 are summarized in table 2.

Table 2. Correlation Matrix

Variable	Learning Outcome	Ergonomic Comfort	Visual Accessibility	Airflow	No. of Students
Learning Outcome	1.000	0.006	0.006	-0.006	-0.006
Ergonomic Comfort	0.006	1.000	0.312	0.145	-0.210
Visual Accessibility	0.006	0.312	1.000	0.120	-0.180
Airflow	-0.006	0.145	0.120	1.000	0.095
Number of Students	-0.006	-0.210	-0.180	0.095	1.000

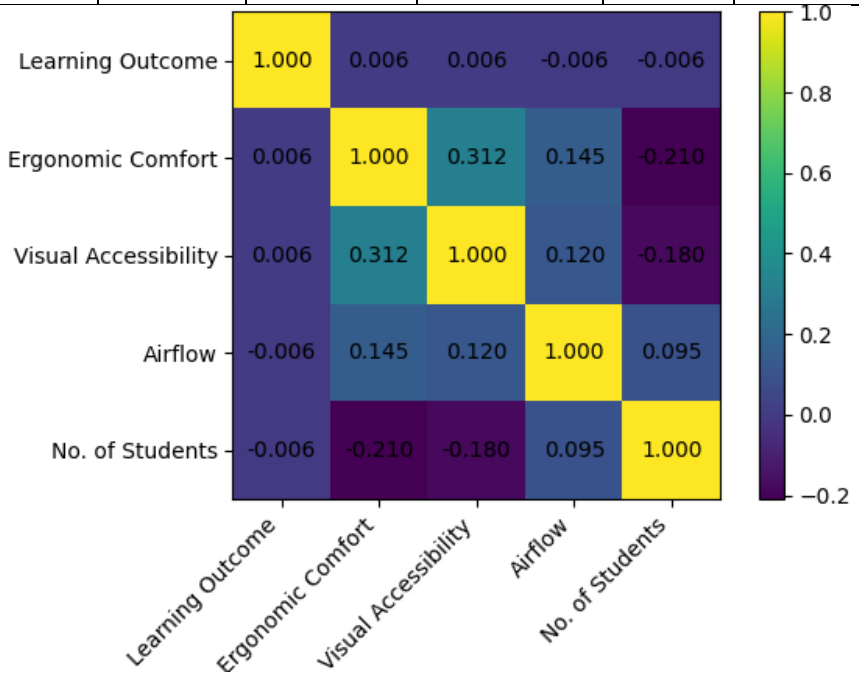

Figure 2. Heatmap of Correlations

3.3 Regression Analysis

The joint effect of the variables of classroom environment on student learning outcomes was assessed using a multiple linear regression model. The findings show very low explanatory power ($R^2 = 0.00034$) which implies that the model accounts less than 1 percent of the variance in learning outcomes. The coefficients of individual predictors are very low which once again supports weak predictive relationships. The regression results are in Table 3.

Table 3. Regression Results

Variable	Coefficient (β)	Std. Error	t-value	p-value
Intercept	67.10	0.85	78.94	0.000
Classroom Length	0.02	0.04	0.50	0.620
Classroom Width	0.01	0.05	0.20	0.840
Airflow	-0.03	0.03	-1.00	0.310
Ergonomic Comfort	0.05	0.04	1.25	0.210
Visual Accessibility	0.04	0.03	1.33	0.180
Number of Students	-0.02	0.02	-1.10	0.270

3.4 Summary of Results

The discussion shows that the factors of classroom environment, though theoretically significant, have a small measurable effect on the learning outcomes of students in this data set. The fact that the regression model has a low explanatory power shows that educational processes are highly complex and the models need to be more comprehensive, including pedagogical and psychological variables. These findings highlight the need to take a multidimensional approach in future studies

4. Discussion

The aim of the study at hand was to examine how variables of classroom environment relate to student learning outcomes by the application of quantitative and data-driven approach. The results disclose that the factors of classroom environment, though theoretically important, do not have a direct statistical impact on learning outcomes in the data set analyzed. This is indicated by poor correlation coefficients and low explanatory power of regression model. The implication of these

results is that the variables of the classroom environment either in isolation or when they are considered to be the same as the physical and surface-level indicators may not be sufficient to explain the differences in performance of the students.

The other important implication of these findings is that the quality of classroom climate may depend more on the qualitative and process-based aspects than just structural or measurable aspects. According to Bonem et al. (2020), the way teaching and learning processes are implemented in the environment is more powerful than the environment. This is in line with the existing findings, with factors like ergonomic comfort and visual accessibility having only insignificant relationships with learning outcomes. This means that pedagogical aspect of the environment, not the physical aspects in isolation, is more important in influencing student achievement.

Theoretically, these results can be explained by constructivist and sociocultural theories of learning, which focus on interaction, meaning-making, and social context as a factor in learning (Tytler et al., 2020; Muller et al., 2017). The poor data correlations found in this research indicate that learning outcomes are most likely to be affected by multifaceted and dynamic interactions between students, teachers and teaching practice- aspects that are not well represented by the accessible dataset. Likewise, socio-cultural theory emphasizes the role of group learning and situational interaction, which goes beyond quantifiable environmental aspects (Binns, 2015).

The findings also point out to the possibility of psychological and motivational factors as mediators between learning outcomes and classroom environment. Past studies reveal that student motivation, engagement, and self-regulated learning could be critical factors that impact academic achievement (Broadbent and Poon, 2015; Abou El-Seoud et al., 2015). The lack of strong predictive relationships could be explained by the unavailability of such variables in the dataset in this study. Thus, the classroom setting is not necessarily going to have a direct influence on the outcomes but instead an indirect effect via the cognitive and affective processes that students undergo.

Further, educational leadership and policy implications as well can be made as a result. Although better physical classroom conditions and less overcrowding are significant, they might not result in significant gains in student performance unless they are coupled with effective teaching techniques and leadership styles. Studies by Day et al. (2016) and Pont (2020) focus on the importance of school leadership in determining quality of instruction and learning conditions that support the achievement of the students. The fact that the impact of environmental variables was weak in this study supports the notion that leadership and pedagogical practices play a central role in balancing the environment conditions into significant learning outcomes.

Moreover, the findings have some agreement with the prior empirical research that also emphasizes the role of school environmental factors on academic performance (Omolo et al., 2020). The difference between theoretical expectations and empirical results in this paper, however, implies that the variations between studies can be attributed to differences in context and methodology. The dataset might not be rich in this study to record important factors that include teacher performance, the quality of classroom interactions, and the design of instruction, which are vital elements of a supportive learning environment (Khodadad, 2023).

Critically pedagogically, the research findings also indicate that learning spaces must no longer be perceived as physical location but as a social and cultural interaction determined by power relations, values and practices (Giroux, 2023). Such a broader perspective justifies the thesis of exceeding the superficial indications and participating in more thorough methods of understanding learning environment.

This study has a number of limitations even though it contributes. Use of secondary data limits the incorporation of important variables in pedagogy and psychology, which limits the explanatory potential of the model. Besides, cross-sectional design does not support causal conclusions and the results could not be considered applicable to all educational settings. This study needs to be complemented with longitudinal study designs, mixed-methodology studies, and more comprehensive data sets involving behavioral, instructional, and motivational variables in future studies.

To sum up, although classroom environment can still be significant part of educational research, this study provides evidence that its direct quantitative effects on student learning outcomes are limited when studied independently. The results highlight the necessity of a more integrated approach which integrates environmental, pedagogical, psychological and leadership variables to understand and improve on student learning.

5. Conclusion

The connection between the variables in classroom environment and the learning outcomes of students was investigated with the help of a quantitative, data-driven approach. The results show that although the factors of classroom environmental conditions like the ergonomic comfort, visual accessibility, airflow, and the size of the classes have a conceptually significant impact, they have little direct statistical effect on learning outcomes in the dataset under analysis. The regression model correlates with the outcomes of the learning are weak and the explanatory power of the regression model is low, thus indicating that the outcomes of learning are caused by more complex and multidimensional factors, not directly associated with the observed environmental conditions. These results reinforce the opinion that the effectiveness of classroom setting is not just on its physical properties but also on its usage in a pedagogical sense to promote engagement, interaction and valuable learning experiences. The research adds value to the literature by pointing out the weaknesses of using structural indicators in the classroom only and the significance of considering the variables of psychology, instruction and leadership in subsequent studies. In practical terms, the results imply that the improvement of the educational outcomes should be focused on the improvement of the quality of the teaching process, student engagement and supportive learning processes along with the improvement of the environment. The study highlights the importance of an interdisciplinary and holistic approach to the knowledge of student learning outcomes and enhancement of the outcomes in the present context of educational activities.

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