

## Neuroarchitectural design and its capacity to improve academic performance with special abilities

El diseño neuro arquitectónico y su capacidad para mejorar el rendimiento académico con capacidades especiales

Isaac Ronald Muñoz Mindiola\*  
Ivette Solange Cevallos Baque\*  
Dario Vidal Ponce Gonzalez\*  
Walther Lider Cevallos Wong\*

### ABSTRACT

The spatial and psychological relationship of students in classrooms according to academic components currently represents 80% of the student's physical environment throughout their career. 12.45% respond to psychological alterations due to stress and mental exhaustion factors, which is why the study is justified in attempting to create spaces that generate relaxation and comprehensive comfort. In the Faculty of Architecture and Urbanism, according to a sample provided by the Student Welfare Department, there is a stress level of more than 68% among FAU students, as determined by a student census, which also revealed the important fact that 5.63% have ASD and psychosensory disorders, which are attributed to their disability. This scientific document will address techniques for establishing comfortable spaces within the Faculty's classroom modules and provide criteria based on cognitive analysis and decision-making. The study evaluates how physical variables in the environment, such as temperature, humidity, and noise, influence the well-being and performance of students at the Faculty of Architecture and Urbanism at the University of Guayaquil. Through systematic measurements, environmental deficiencies that affect comfort and

\* Master's Universidad de Guayaquil isaac.munozm@ug.edu.ec;  
<https://orcid.org/0009-0005-5220-1343>

\* Master's Universidad de Guayaquil ivette.cevallosb@ug.edu.ec;  
<https://orcid.org/0000-0003-1789-7726>

\* Master's Universidad de Guayaquil dario.ponceg@ug.edu.ec;  
<https://orcid.org/0009-0006-1852-0620>

\* Master's Universidad de Guayaquil walther.cevalloswon@ug.edu.ec;  
<https://orcid.org/0000-0003-1172-3346>

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learning were identified. Architectural improvements are proposed that integrate principles of neuroarchitecture and bioclimatic design. However, the focus of this study is characterized by the function of bioclimatic criteria as indicators that contribute to the cognitive comfort of people with ASD and psychosensory disorders within the Faculty of Architecture and Urbanism. It is concluded that the study of individuals' own faculties contributed to deriving criteria for sizing and active contact with natural spaces that led to a 65% reduction in psychosensory disorders and a 50% increase in concentration within the classroom.

**Keywords:** classroom, well-being, universities

## RESUMEN

La relación espacial y psíquica de los estudiantes en los salones de clase según los componentes académicos actualmente representan un 80% del medio físico del estudiante en toda su carrera, un 12,45% responden a alteraciones psicológicas por factores de estrés y agotamiento mental por lo que el estudio se justifica al tratar de generar espacios que generen relajación y confort integral. En la Facultad de Arquitectura y Urbanismo según una muestra proporcionada por el Departamento de Bienestar Estudiantil, existe un nivel de estrés de más del 68% de los estudiantes de la FAU, determinado por un censo estudiantil el cual arroja también como dato importante que el 5,63% tienen TEA y alteraciones psicosensores las cuales se atribuyen a discapacidad. El presente documento científico abordará las técnicas para establecer espacios confortables dentro de los módulos de aulas de la Facultad y proporcionar criterios desde un análisis cognitivo y de toma de decisiones. El estudio evalúa cómo variables físicas del entorno como temperatura, humedad y ruido influyen en el bienestar y rendimiento de los estudiantes de la Facultad de Arquitectura y Urbanismo de la Universidad de Guayaquil. A través de mediciones sistemáticas, se identificaron deficiencias ambientales que afectan el confort y aprendizaje. Se proponen mejoras arquitectónicas que integran principios de

neuroarquitectura y diseño bioclimático. Mas no obstante el enfoque del presente estudio se caracteriza en la función de los criterios bioclimáticos como indicadores que aporten al confort cognitivo de las personas con TEA y alteraciones psicosenoriales dentro de la Facultad de Arquitectura y Urbanismo. Se concluye que el estudio de las facultades propias de los individuos aporato a derivar un criterio de dimensionamiento y contacto activo con espacios naturales que propiciaron una disminución del 65% de alteraciones psicosenoriales y aumentaron en un 50% la concentración dentro del aula de clase.

**Palabras clave:** aula de clase, bienestar, universidades

## INTRODUCTION

The purpose of this research is to examine the impact of the physical environment of classrooms on the academic performance and well-being of university students, taking into account that educational spaces are not simply functional containers, but active components that influence teaching-learning processes (Barrett et al., 2015). Several studies have shown that environmental factors such as temperature, noise level, light, and relative humidity have a considerable impact on students' ability to concentrate, remember information, motivate themselves, and maintain a positive emotional state (Cheryan et al., 2014; Evans, 2006).

Studies have shown that the physical environment can significantly affect a person's mood, behavior, and overall well-being. For example, spaces with natural light, a view of nature, and comfortable furniture can create a calm and supportive environment (Papanastasiou et al. 2022), while spaces with poor lighting, clutter, and inadequate ventilation can increase levels of anxiety and stress.

Neuroarchitecture can also help address specific psychological conditions by using sensory stimulation to promote relaxation and reduce symptoms of anxiety, depression, and post-traumatic stress disorder (PTSD). For example, incorporating elements such as natural light, water features, and plants can help reduce stress levels and promote a sense of calm, while the use of textures, colors, and patterns can be used to create a sensory-rich environment that engages the brain and reduces symptoms of anxiety.

In spaces, it is also important to consider the needs and preferences of the individual and their relationship with the environment (Unni et al. 2022). For example, some people may prefer a quiet and serene environment, while others may benefit from a more active and engaging space, but these spaces must be in harmony with nature.

The interaction between bioclimatic architecture and neuroarchitecture allows for the creation of spaces that are not only sustainable and efficient, but also healthy and

adapted to human needs. This integration is key to the future of architectural design, where people's well-being and respect for the environment must go hand in hand.

In this context, the study pays special attention to three essential environmental factors: temperature, noise, and humidity, changes in which can have beneficial or detrimental impacts on the cognitive performance and well-being of users (Wargocki & Wyon, 2013). The research is being conducted in six selected classrooms at the Faculty of Architecture and Urbanism of the University of Guayaquil, using a method based on systematic measurements, direct observation, and comparative analysis. The strategy implemented incorporates the fundamentals of bioclimatic design, focused on maximizing passive thermal comfort and energy efficiency, drawing on neuroarchitecture, a growing discipline that analyzes how the built environment affects the brain, emotional, and behavioral activity of individuals (Sternberg & Wilson, 2006; Eberhard, 2009). This combination facilitates a more detailed understanding of the role of physical space in human behavior, especially in formal learning environments.

This study aims to determine the elements that restrict or promote academic performance, as well as to propose architectural interventions that optimize environmental conditions in university classrooms. The findings are expected to promote the creation of design guidelines that are more focused on human comfort and centered on the overall well-being of students, thereby fostering more inclusive, healthy, and energy- and functionally-efficient educational environments.

This chapter will address the influence of physical environmental variables on the university educational environment, their relationship to architectural design, and how neuroarchitecture and the bioclimatic approach allow for significant improvements to be proposed. Field-measured data will be analyzed and practical redesign solutions will be discussed.

Historically, the quality of the physical environment in educational settings has been underestimated, despite its direct influence on students' well-being and cognitive performance. In Ecuador, particularly at the Faculty of Architecture and Urbanism of the University of Guayaquil, classrooms have been found to be inadequate in terms of local weather conditions and students' sensory demands.

The main challenge lies in the continuity of spaces built without environmental comfort standards, where high temperatures, unmitigated outside noise, and poorly regulated humidity levels predominate. These circumstances cause physical discomfort, mental fatigue, and reduced concentration, impacting the teaching-learning process.

The hypothesis guiding this study argues that optimizing environmental factors, particularly temperature, humidity, and noise levels, through architectural tactics based on neuroarchitecture and bioclimatic design, will have a positive effect on student performance and well-being. This conjecture is based on international research that has shown that thermally and acoustically pleasant environments foster more favorable cognitive, emotional, and social conditions for the learning process. Therefore, a practical study is proposed that not only collects environmental information from

classrooms but also suggests specific redesign solutions, merging scientific knowledge with contextual architectural practice.

The study of psychological conditions within study spaces is an important field of research that focuses on understanding how the physical environment of study spaces affects patients' mental health and well-being (Erkan 2021).

Physical study spaces are designed to help people recover from injuries or illnesses that affect their physical abilities (Pico et al. 2021). However, these spaces can also have a significant impact on patients' psychological well-being. For example, the design of a study space can influence patients' perceptions of their progress, motivation levels, and overall satisfaction with their treatment.

Psychological study spaces in Ecuador provide treatment focused on patient dissipation through activities in semi-open spaces, periodic testing, prescribed medication, and personalized interaction. This model has had a 46% effectiveness rate across its 42 accredited psychological study centers throughout the country (Álvarez Córdova et al. 2020).

Research in this field explores the impact of psychological treatment using complementary elements such as natural light, colors, sound, public spaces, green areas, and furniture to reduce stress levels and improve the overall well-being of patients. Other factors that can be explored include the design and organization of space, the degree of privacy and social interaction, and the presence of visual distractions or stressors.

Psychological conditions that can be studied within study spaces include anxiety, depression, post-traumatic stress disorder (PTSD), and adjustment disorder. These conditions, based on neuro sign standards, can have a significant impact on patients' recovery process, as well as their overall quality of life.

## MATERIALS AND METHODS

Traditionally, a descriptive experimental methodology with a mixed analysis method is used, but in this case, the interrelation between two approaches returns the study to a search for information and data that can reveal the real conditions of the phenomenon; therefore, a mixed-method methodology will be used. The evaluation of the current study model and its characteristics plays a circumstantial role in understanding the particular condition of individuals with ASD or psychosensory impairments, for which their current conditions will be recorded as determined in the following table:

**Table I .** *Characterization of the psycho-sensory impairments of FAU-UG students.*

Period	Faculty	Impairment	Percentage	Status
2024-2025 IIC	Architecture and Urban Planning	Psychosocial	4.26	Second enrollment

2024- 2025 IIC	Architecture and Urban Planning	Stress	68.00	First - Second enrollment
2024- 2025 IIC	Architecture and Urban Planning	TEA	5.63	Third enrollment
2024- 2025 IIC	Architecture and Urban Planning	Psychosensory disability	2.25	Second enrollment

Note: Data from the FAU-UG Student Welfare Department (2024)

In recent years, the number of students with disabilities has grown by 3% (data taken from the average – FAU-UG Student Welfare), which means that classrooms and teaching staff must be trained and updated to cater for a comprehensive and inclusive educational model that was not conceived at the beginning of the faculty. The following table shows the case of students with psychosensory impairments enrolled in this second semester of the current year, identifying that the dropout rate or number of enrollments resulting from repeating the course is more consistent in this type of social stratum. This background information made it possible to visualize that part of the educational structure does not generate support for disabilities, which is growing in relevance semester after semester. The decision-making method is used as a tool to determine individuals' preferences through their collective experience in analyzing the situation, the problem, the decision, and the potential problems encountered by each individual, generating a weighted average of results.

For the development of the experimental methodology, a sample of six classrooms from the Faculty of Architecture and Urbanism of the University of Guayaquil was selected: 4<sup>a</sup>- 101, 4<sup>a</sup> – 001, B – 113, 4<sup>a</sup> – 009, B – 00, 4<sup>a</sup> – 112. For measurement using specialized equipment. The following results were obtained from the samples:

**Table2 .** *Bioclimatic analysis of the FAU-UG classroom sample.*

Classroom	Temperature (°C)	Humidity (%)	Noise (dB)	Problems detected
4A-001	31	43	72	External noise, heat
4A-101	31	43	66-68	Excessive light, uncomfortable furniture
4B-113	24	57	60	Poor lighting, uncomfortable stools
4A-009	26	43	50	Average noise, indirect lighting
4B-001	30	43	64-65	Noise in front and rear areas

4A-112	31	43	71	High temperature, uncomfortable furniture
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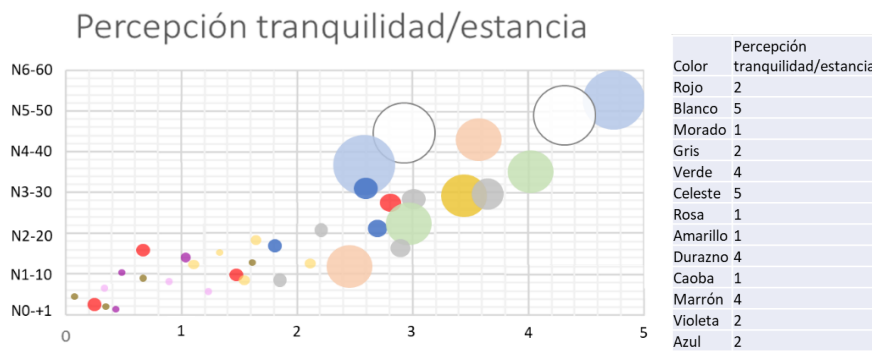
Note: Prepared by the authors.

Alarming patterns were identified. In five of the six classrooms studied, the temperature exceeded 30°C, causing lasting thermal discomfort. In all classrooms, noise levels exceeding 60 dB were recorded, which impacted concentration. Humidity remained at acceptable levels, although there were no effective control systems. Deficiencies in lighting and furniture were also highlighted as factors that exacerbate student discomfort. These findings highlight an urgent need for action in educational environments based on technical and human criteria, in which architecture is interpreted as a tool for simplifying the learning experience.

**RESULTS**

Indicators within the psychological and psychosensory perception of students were taken into account, with color, shape, interaction with green areas, and social integration as optimal fundamentals. The scatter plot established levels of acceptance by the users surveyed (60), ranging from a level of 0 to a level of 5 in relation to color and its minimum or maximum weighting to form the dispersion of choice.

**Figure 1 .** Scatter plot for color choice.



Note: Prepared by the authors.

The colors proposed focused on the perception of the patient's emotional health and how these colors stimulate tranquility and the stay of users within a psychiatric center. The established color palette is based on current color trends in treatment spaces. According to the scatter plot, the most appropriate colors are white, blue, green, peach, and brown, as they obtained the highest acceptance score from users (60).

### 3 . Spatial matrix of form by structure.

Matriz espacial de forma			
Aulas	Cuadrada	Lineal	2
	Cuadrada	Lineal con esquinas curvas	2
Zonas comunes	Circular	Excentrica y combinada con forma recta	3
	Circular	Concentrica	3
	Cuadrada	Simple	1
Espacios exteriores	Circular	Simple	1
	Circular	Concentrica	3
	Cuadrada	Simple	1

Note: Prepared by the authors.

The shape choices are based on the conceptualization of shape and structure, whether the shape is maintained or whether combinations of shapes generate succession without creating voids, complex transit spaces, or spaces with no apparent exit. The framework of options is designed in accordance with existing analogous models and design guidelines for functional neuroarchitecture spaces. The weightings are established in ranges from 1 to 3, with the highest being the best selection.

**Table4 . Positive and negative perceptual selection of green and social areas.**

Selección perceptiva		
Denominador	Positiva	Negativa
Interacción con áreas verdes		
Integración social		

Note: Prepared by the authors.

Interaction with green areas and social integration generate a positive perception of this model integrated into buildings as part of psychological treatment.

The information collected and studied facilitates the formation of a direct relationship between environmental conditions in classrooms and the quality of the educational environment. From the point of view of neuroarchitecture, we can argue that the design of space not only accommodates educational processes, but also regulates, enhances, or restricts them.

High temperatures cause fatigue, reduce the ability to concentrate, and impair emotional predisposition toward the learning process. Excessive noise hinders auditory perception, causes stress, and decreases communication effectiveness. Insufficient light, whether excessive or insufficient, strains vision and alters circadian rhythms, which are essential for maintaining concentration and alertness.

From a bioclimatic design perspective, there are several possibilities for passive improvement: cross ventilation, use of insulating materials, improved openings for light entry and solar control, and the incorporation of vegetation for heat regulation. All of these tactics make it possible to intervene without having to resort solely to costly or high-energy technological solutions. In terms of proposals, a complete restructuring is suggested that includes: acoustic panels on walls and ceilings, thermal coatings, ergonomic furniture, natural ventilation systems, dimmable LED lighting, and the restructuring of furniture to enhance comfort and interaction.

The debate not only corroborates the initial hypothesis, but also provides an interdisciplinary view of how the built environment should meet the cognitive, sensory, and emotional demands of students. In this context, architectural design ceases to be an independent technical practice and becomes an educational tool that promotes relevant and sustainable learning.

## CONCLUSIONS

The factors that shape spatial perception, such as the environment, ergonomics, color, and shape in the classroom, particularly those related to appropriate temperature, stable sound, and humidity, are crucial elements that have a direct and indirect impact on the academic performance and mental well-being of university students. However, an additional criterion was found to be relevant in the analysis of color, with the degree of concentration and tranquility provided by the correct choice. This research has shown that the lack of control over these components causes thermal discomfort, continuous distractions, and fatigue, impacting the ability to focus, motivation, and the efficiency of the educational process.

The results indicate that a large number of the classrooms examined exhibit temperatures above the suggested standards, noise levels above the permitted limits, and poor lighting for long-term academic activities. These physical circumstances not only diminish the quality of the educational environment but also maintain a learning system that hides the cognitive and sensory needs of the student.

Based on this analysis, it can be deduced that the implementation of neuroarchitecture and bioclimatic design principles can lead to significant and sustainable changes in the educational field. These disciplines provide scientific tools and methods that facilitate the creation of healthier, more functional spaces that are in line with human needs.

Additionally, it reaffirms the importance of reconsidering the architectural design of university classrooms from a multisensory and user-centered approach, taking into account elements such as natural ventilation, sound insulation, heat regulation, effective lighting, and furniture ergonomics.

In conclusion, this chapter provides specific evidence and suggestions for increasing environmental comfort in classrooms, which not only influences academic performance but also promotes a more inclusive, fair, and sustainable education.

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