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Assessment of Indoor Environmental Quality in Elementary School Classrooms in North Louisiana

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Abstract

This study assesses indoor environmental quality (IEQ) in elementary school classrooms in North Louisiana and examines its potential implications for student comfort and learning performance. Indoor environmental factors, including lighting, thermal conditions, acoustics, and air quality, play a critical role in creating effective learning environments. Field measurements were conducted in six classrooms in an elementary school to collect data on illuminance, color temperature, surface reflectivity, temperature, relative humidity, noise levels, and indoor air quality. The measured values were compared with recommended standards identified through a comprehensive literature review. The results indicate that indoor air quality generally met recommended guidelines, while several environmental parameters deviated from recommended ranges. Noise levels exceeded recommended acoustic comfort ranges, relative humidity and temperature were below recommended levels, and variations were observed in lighting uniformity, illuminance, color temperature distribution, and wall reflectivity. These deviations may influence visual comfort, thermal comfort, attention, and overall classroom learning conditions. The findings highlight the importance of region-specific assessments and targeted improvements in lighting design and environmental control systems to support healthier and more effective learning environments in elementary schools.

Keywords
Learning environment, Classroom ergonomics, Elementary education, Visual and thermal comfort.

1. Introduction
American classrooms have struggled with appropriate lighting conditions since the introduction of compulsory education in the late nineteenth and early twentieth centuries (Gyure, 2025). Anecdotal evidence suggests students strained their eyes to read in classrooms with low light conditions, which resulted in increased reports of myopia. Even in modern times, educational settings try to achieve appropriate lighting conditions in classrooms and for students with disabilities, such as visual light sensitivity (Sproul *et al.*, 2021), autism spectrum disorder (Martin & Wilkins, 2022), and visual impairments (Ahmad Najmee *et al*., 2024). Lighting conditions also affect students' cognition and learning (Gao *et al*., 2025). Therefore, studying optimal lighting parameters in classrooms serves to benefit students.

1.1 Problem statement
Despite the recognized importance of indoor environmental quality, the environmental conditions of elementary school classrooms in North Louisiana, particularly lighting-related parameters, have not been extensively studied. There is limited empirical data documenting illumination levels, color temperature, surface reflectivity, and associated environmental factors in these learning spaces. Figure 1 (generated by generative AI tool) illustrates a representative classroom layout and identifies the key environmental parameters evaluated in this study. This research aims to address this gap by systematically assessing classroom lighting and related environmental conditions to determine their alignment with recommended standards and best practices for early childhood education.

Figure 1**.** Environmental parameters for an elementary classroom.

1.2 Objective
The objectives of this study are to (1) review existing literature to identify recommended and safe ranges for selected classroom environmental parameters, including lighting fixtures, illumination characteristics, temperature, humidity, sound levels, window conditions, surface reflectivity, color temperature, wall color, and indoor air quality, and (2) assess the current environmental conditions of selected elementary school classrooms in Natchitoches Parish through on-site observations and measurements to evaluate their compliance with established standards.

2. Literature survey

Chauca *et al.* (2024) reviewed studies examining the influence of classroom lighting on students' academic performance and emphasized that appropriate lighting design is essential for human comfort and learning effectiveness. Their analysis focused on variations in lighting intensity and color temperature, evaluating student attention, concentration, and long-term memory under different classroom lighting conditions. The study identified optimal ranges of 350–1000 lux for light intensity and 40 b00–5250 K for color temperature as most favorable for attention and memory performance.

Lekan-Kehinde and Asojo (2021) reviewed the impact of lighting on children's learning environments and found that lighting significantly influences visual, cognitive, and behavioral functioning by affecting concentration, alertness, and mood. The surveyed studies used qualitative, quantitative, mixed, and quasi–mixed methods, measuring outcomes such as standardized test scores, reading performance, concentration, behavior, and mood under varying lighting conditions. Their findings, supported by Mott et al., showed that color temperature and illuminance levels (e.g., 6500 K and 1000 lx) improved reading performance, task-switching ability, concentration, and cognitive performance compared to lower lighting levels.

Fercha *et al.* (2025) conducted research focused on the relationship between visual comfort and natural lighting in classrooms, emphasizing its impact on students' performance. The study employed the emergent tool Analytical Hierarchy Process (AHP) to identify the factors, climate, windows configuration, wall and ceiling color, and furniture design, that most significantly influence visual quality and comfort. The findings highlighted that daylight quality in classrooms depends on several key factors such as climate conditions, time of day, window design, orientation, and wall color. The study found solutions include controlling glare through shading elements without obstructing essential daylight, using flexible furniture arrangements, and implementing smart lighting systems that adjust artificial lighting according to daylight availability. Additionally, Fercha *et al.* (2025) emphasized the importance of optimizing window orientation and size to ensure consistent daylight penetration.

Uyal and Umar (2022) examined how the physical environment of a university classroom influences students' comfort, academic performance, and musculoskeletal discomfort. Using a two-part questionnaire completed by 383 students, the authors evaluated factors such as lighting, temperature, chair design, and projector quality, together with musculoskeletal discomfort. Their findings showed that classroom conditions did not significantly affect comfort, but they did influence academic performance, especially through sunlight exposure, temperature, and projector visibility, and also affected musculoskeletal discomfort across demographic groups. Uyal and Umar (2022) stated that absenteeism among students, teachers, and staff decreased by 2–7.5 percent in green buildings, while student performance improved by 8–19. Overall, the study concluded that classroom environmental parameters can differentially impact students' performance.

Anake and Nnamani (2023) reviewed global studies on indoor air quality in day-care centers to assess the levels, sources, and health risks of chemical pollutants affecting young children. Their analysis applied the PRISMA systematic review method to screen 207 studies, ultimately selecting 37 that met strict inclusion criteria focused on indoor chemical pollutants such as particulate matter (PM10, PM2.5), carbon dioxide, carbon monoxide, formaldehyde, VOCs, nitrogen dioxide, ozone, benzene, Sulphur dioxide, and radon. The authors reported that particulate matter was the most frequently monitored pollutant, with concentrations ranging widely, for example, PM10 levels from 0.116 to 1920.71 $\mu g/m^3$ and PM2.5 from 0.279 to 260.74 $\mu g/m^3$, often exceeding WHO and USEPA guidelines. The study aimed to provide a global overview of the predominant indoor chemical pollutant levels and propose strategies for enhancing IAQ. Anake and Nnamani (2023) findings showed that while pollutants such as nitrogen dioxide and carbon monoxide generally remained within international standards, exceedances were common for PM, CO_2, VOCs, and ozone. Overall, the study concluded that indoor air quality is insufficiently monitored worldwide and that pollutant levels frequently surpass recommended limits, affecting comfort, performance, and dropping the students' classes experience.

Pulimeno *et al.* (2020) examined the relationship between indoor air quality in schools and students' academic performance, emphasizing that this factor can improve both health and learning outcomes. Their perspective review synthesized evidence on key IAQ parameters, such as ventilation, temperature, humidity, CO_2, volatile organic compounds, and pollutants from traffic or building materials. Pulimeno *et al.* (2020) obtained the data by drawing on epidemiological studies, cohort analyses, and experimental research. The authors highlighted that CO_2 levels above 1000–1500 ppm, PM2.5 and PM10 concentrations exceeding WHO guidelines, and exposure to VOCs or NO_2 are consistently associated with reduced attention, lower standardized test scores, and diminished cognitive performance. As they note, “standardized tests administered to pupils exposed to poor IAQ. systematically result in worse outcomes compared to students staying in healthy classroom environments” Pulimeno *et al*.(2020). Their review also found improved reading and math scores following increased ventilation rates, and better cognitive development in schools with lower traffic-related pollution. Overall, the Pulimeno *et al.* (2020) concluded that IAQ is a critical yet neglected determinant of student performance and proposed evidence-based recommendations, to support healthier and more effective learning environments.

Feldmann *et al.* (2021) evaluated indoor environmental quality and health concerns among employees of a public elementary school to determine whether reported medical symptoms, including respiratory issues, headaches, and reproductive conditions, were associated with workplace environmental exposures. Their investigation included a full-building visual inspection, HVAC assessment, mold and dampness evaluation using the NIOSH Dampness and Mold Assessment Tool, real-time measurements of temperature, humidity, CO_2, and CO, and confidential employee interviews documenting symptoms and medical histories. As the authors explain, the objective was “to determine if the school had mold or other IEQ issues and if the medical and reproductive conditions of concern could be associated with the building” Feldmann *et al.* (2021). The evaluation found no evidence of active mold growth, though past water intrusion and minor moisture issues were documented. Several HVAC units were obstructed or aging, and CO_2 levels in seven of eight classrooms exceeded recommended ventilation guidelines, indicating insufficient outdoor air supply. Employees reported frequent work-related nasal congestion and headaches at rates higher than those observed in buildings without IEQ complaints, though reproductive health outcomes were not elevated compared with national data. Overall, the study concluded that while no specific environmental hazard explained the medical concerns, inadequate ventilation and comfort-parameter deviations likely contributed to reported symptoms, underscoring the need for HVAC improvements and a structured indoor environmental quality management program.

Ranđelović *et al*. (2024) analyzed the energy efficiency performance of school buildings by evaluating the impact of thermal insulation upgrades and window replacement through cost benefit analysis and detailed energy simulations. Their study applied a parametric modeling approach to test multiple retrofit scenarios, including façade insulation, roof insulation, glazing upgrades, lighting modernization, and alternative heating systems, under Serbia’s temperate continental climate conditions. The goal was to identify strategies that maximize energy savings, reduce CO_2 emissions, and provide the most profitable return on investment. The simulations showed that window replacement alone produced lower than expected energy savings, while wall and roof insulation delivered the most substantial improvements, reducing annual energy use by up to 152 kWh/m² and CO_2 emissions by 41 kg/m². Optimal insulation strategies improved overall energy efficiency by 48–56% and reduced emissions by 45–56%, and lighting modernization further enhanced performance. Overall, Ranđelović *et al*. (2024) concluded that climate specific insulation thickness, appropriate glazing selection, and integrated retrofit packages are essential for achieving cost effective energy efficiency improvements in school buildings.

Yang and Jeon (2020) investigated how different correlated color temperatures (CCT) of LED lighting influence university students’ visual sensation, lighting perception, and cognitive performance in a real classroom environment. Their study exposed 60 students to six lighting configurations combining three CCT levels (3000 K, 4000 K, 5700 K) and two illuminance levels (650 lx and 1050 lx). As Yang and Jeon (2020) report, “An increase in correlated color temperature (CCT) led to an increase in brightness sensation,” although this did not translate into a linear improvement in comfort. Instead, “A CCT of 4000 K was considered as the optimum for lighting comfort in educational settings.” Yang and Jeon (2020). Overall, the study concluded that optimal CCT is more influential than increased illuminance in moderately lit classrooms, suggesting that tuning color temperature, particularly around 4000 K, may enhance comfort and certain aspects of cognitive performance.

Barrett *et al.* (2015) conducted one of the most comprehensive investigations into how classroom design affects primary school students’ academic progress. The study was performed in 27 schools and more that 100 classrooms to identify the impact of the physical classroom features on the academic progress of the students. Using a holistic, multi-level modelling approach, the study captured the full range of sensory and environmental factors influencing learning. Their analysis showed that natural light, temperature, and air quality accounted for roughly half of the total design impact. Barrett et al. (2015) found seven key parameters that have the bigger impact including light, temperature, air quality, ownership, flexibility, complexity, and color. These findings demonstrate that classroom design exerts a measurable and non-trivial influence on learning outcomes, supporting the argument that optimizing environmental quality, especially lighting, thermal comfort, and visual organization, can significantly enhance student performance.

2.1 What is Being Done

Existing research has extensively examined the effects of classroom lighting, indoor air quality, thermal comfort, surface reflectivity, and related environmental parameters on students' comfort, health, and academic performance. Prior studies have largely focused on identifying optimal ranges for lighting intensity, color temperature, daylight integration, ventilation, and building design features, as well as their cognitive, behavioral, and health-related impacts. These studies have provided evidence-based guidelines and design strategies applicable to a variety of climatic and geographic contexts.

2.2 Research Gap and Rationale

Despite the breadth of international and national studies, there is a notable lack of empirical research focused on elementary school classrooms in North Louisiana. The region presents unique environmental and climatic conditions that are not adequately represented in the existing literature, which is predominantly based on temperate, arid, or cold climates. North Louisiana experiences high humidity, high UV index and sunlight, frequent rainfall, seasonal pollen exposure, and mold-related concerns due to its proximity to coastal and moist environments. These factors may significantly influence indoor environmental quality, lighting performance, and occupant comfort in ways that differ from previously studied regions.

2.3 Reason for Conducting This Research

To date, no comprehensive field-based study has been identified that evaluates classroom lighting and associated environmental parameters in Louisiana elementary schools. Given the region's distinct weather patterns and documented concerns related to moisture, mold growth, and airborne allergens, it is critical to assess whether existing classroom conditions align with recommended standards and whether nationally or internationally derived guidelines are fully applicable in this context. This study seeks to address this gap by systematically evaluating classroom environmental conditions in North Louisiana, providing localized data that can inform design improvements, maintenance practices, and policy decisions aimed at creating healthier and more effective learning environments for young students.

3. Methodology

3.1 Data collection

Design and Sample: A preliminary study of one school with six classrooms has been presented in this paper. This study employed a mixed-methods design to collect both quantitative and qualitative industrial engineering measures of physical learning environments. A convenience sample was used to collect data from six classrooms in a laboratory school in central Louisiana. A laboratory school was chosen because of its affiliation with a university designed with the intent for training new teachers and conducting educational research. The school was built with an open design learning concept (ODLC) that encouraged student collaboration and engagement. The ODLC also used space to meet the needs of diverse learners and incorporated multiple instructional technologies, such as whiteboards, iPads, and computers. Of the six classrooms included in this study, two were first grade, two were fourth grade, and two were fifth grade. This sampling approach within the school allowed for comparisons between lower and upper elementary grade levels.

Data Collection Procedures: Researchers obtained written permission from the school principal to secure entry into the school and collect data. Teachers were also notified. For optimal measurement conditions, data was collected while teachers and students were not in the rooms. Each classroom was sketched to identify the size of the instructional area and defining features, such as desk placement and smaller learning centers. Qualitative and quantitative measures were completed. Statistical analyses were conducted to test the hypothesis that environmental conditions were within the prescribed range.

3.2 Data analysis

This section discusses the definitions and recommended limits of each parameter including noise, humidity, temperature, air quality, window design, color temperature, luminance, light fixture, wall color and their respective standard ranges recommended by literature reviews.

Reflectivity

Reflectivity is the measure of the effectiveness of a surface in reflecting radiant energy. It is expressed as a percentage of the light that bounces off the surface compared to the light that hits it. In a classroom, reflectivity is used to distribute light efficiently. High ceiling reflectivity ensures that light is bounced back down toward the desks, while moderate wall reflectivity prevents dark spots without creating glare. Barrett *et al*. (2015) found that the parameters for adequate reflectivity levels in a school classroom should be 80% for the ceiling and 50 to 60% for the walls.

Sound and Noise

Sound is a form of energy produced by vibrations traveling through a medium (air, water, or solids) as pressure waves, which are detected by the ears. Noise is defined subjectively as unwanted, unpleasant, or disruptive sound. A logarithmic unit used to measure the intensity or loudness of sound is the decibel (American Speech-Language-Hearing Association, n.d.). According to ANSI (2010), the maximum limits for unoccupied classroom noise should be 35 dBA, with peaks not exceeding 55 dB, and reverberation times should not exceed 0.6 seconds to ensure clear speech communication (Pugh et al., n.d.).

Humidity

Humidity is a quantity representing the amount of water vapor in the atmosphere or in a gas. The most common measurement is Relative Humidity (RH). It expresses the current amount of water vapor as a percentage (%) of the maximum amount the air could hold at its current temperature (Illinois Department of Public Health, n.d.).

Temperature

Temperature is the degree or intensity of heat present in a substance or object. It is expressed according to a comparative scale (Celsius or Fahrenheit) and measured by a thermometer. Maintaining an optimal thermal environment is key to avoiding student fatigue (Barrett *et al.*, 2015).

Air Quality

Air quality refers to the level of pollutants in the atmosphere and measures how clean or polluted the air is at a specific location. Poor air quality has been directly linked to decreased student performance (Sima *et al.*, 2020). The most common measurement used to describe air pollution is the Air Quality Index (AQI), a scale that ranks pollution levels from 0 to 500, where lower numbers indicate cleaner and healthier air. This index evaluates several key pollutants, including PM2.5, which are fine particles measuring 2.5 micrometers that can penetrate deep into the lungs and the cardiovascular system (Centers for Disease Control and Prevention, n.d.). It also measures PM10, or coarse particulate matter, consisting of particles up to 10 micrometers such as dust, pollen, and mold. Other pollutants include formaldehyde (HCHO), a colorless and flammable gas commonly found in pressed-wood products and adhesives that is recognized as a carcinogen and irritant (Illinois Department of Public Health, n.d.), and volatile organic compounds (VOCs), which are chemicals that easily evaporate at room temperature and are emitted from paints, perfumes, and cleaning products.

Window Conditions

Windows serve a vital restorative function. In a learning environment, windows contribute to stress reduction and improvement in cognitive performance. The Window-to-Wall Ratio (WWR) is a technical measure used in architecture and environmental engineering to express the percentage of a building's exterior wall area that is composed of windows. It is calculated by dividing the total window area by the total wall area (Zhang *et al*., 2024).

Color Temperature

Color temperature is a method of describing the color characteristics of light, ranging from “warm” (yellowish) to “cool” (bluish), and is measured in degrees Kelvin (K). Research shows that color temperature directly impacts the circadian rhythm and cognitive arousal of children. Higher Kelvin values (cool white light) are associated with improved concentration and task performance. Zeng *et al*. (2024) specifically found that certain temperatures improve cognitive outcomes in primary students by mimicking natural daylight patterns (Barrett *et al.,* 2015; Zeng *et al.,* 2024).

Luminance
In this context, luminance, specifically referred to as illuminance, is the total luminous flux incident on a surface per unit area, measured in lux. Maintaining proper light intensity is critical for visual comfort during reading and writing tasks; while insufficient light leads to eye strain and lethargy, excessive light causes uncomfortable glare. According to Zeng *et al.* (2024), maintaining levels between 300 and 500 lux provides the necessary visual clarity for primary school students to process information effectively, ensuring an optimal balance for academic performance.

Light Fixtures
Light fixtures represent the physical hardware used to house lamps and distribute light throughout space. The industry has seen a significant shift toward LED panels, as they offer flicker-free, dimmable, and energy-efficient lighting solutions. Research by Mott *et al.* (2012) into "Dynamic Lighting" fixtures, which adjust intensity and color throughout the day, indicates that these specialized LED setups significantly improve student focus and learning speed when compared to traditional, static fluorescent lights

Wall Color
The selection of specific hues and tones for the interior vertical surfaces of a learning environment plays a major role in both "individualization" and "stimulation." Color psychology is a key factor here; Barrett *et al*. (2015) found that cool tones, such as blues and greens, act as restorative and calming influences that reduce overstimulation in 10-year-olds. By utilizing these colors, educators can create a balanced environment that supports sustained attention and helps students manage complex tasks more effectively.

3 . Results
Table 1 lists the parameters and their acceptable ranges according to the available literature and standards. This table also lists the collected data from 6 different classrooms in an elementary school in Central Louisiana. Figure 2 presents the measured noise levels in the six classrooms, showing values ranging from 42 to 47 dBA, which little above the recommended acoustic comfort range of 35–40 dBA and well below the maximum allowable limit of 75 dBA. These results indicate that classroom sound conditions are generally conducive to focused learning. Correspondingly, Table 1 summarizes these findings and confirms compliance with established acoustic standards.

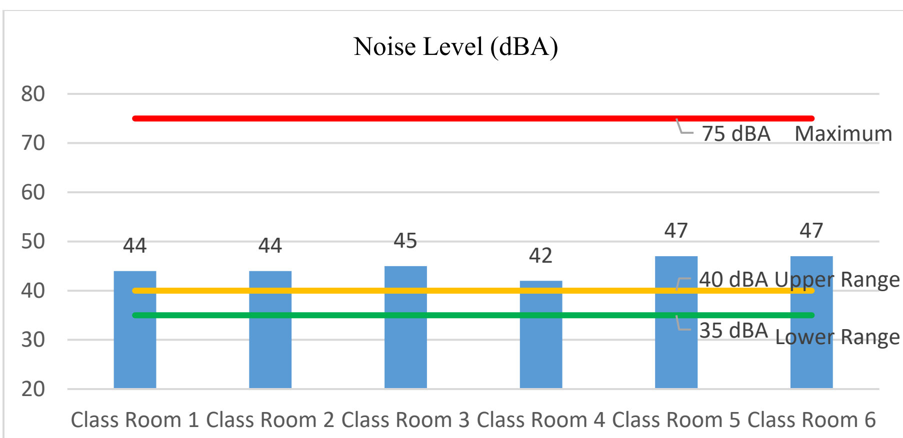

Figure 2. Classroom noise levels (dBA) compared with recommended lower (35 dBA), upper (40 dBA), and maximum (75 dBA) limits.

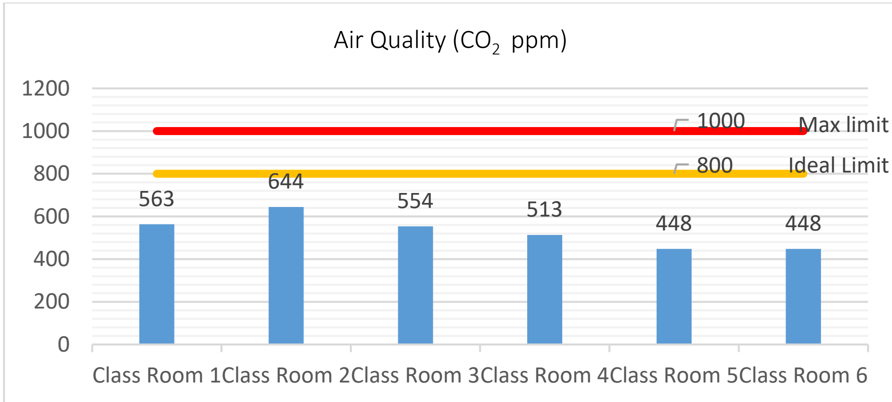

Figure 3. Classroom CO_2 levels (ppm) compared with the ideal (800 ppm) and maximum (1000 ppm) limits.

Figure 3 illustrates the measured indoor air quality in terms of CO_2 concentration, with values between 448 and 644 ppm across all classrooms. As summarized in Table 1, these levels remain well below the maximum recommended limit of 1000 ppm and close to the ideal threshold of 800 ppm, suggesting adequate ventilation and favorable indoor air quality conditions that support student comfort and cognitive performance.

The relative humidity results shown in Figure 4 indicate values ranging from 37% to 47%, which are below the recommended comfort range of 60–65% as listed in Table 1. While these levels do not exceed maximum limits, the consistently lower humidity suggests a potentially dry indoor environment, which may affect thermal comfort and occupant well-being over extended periods.

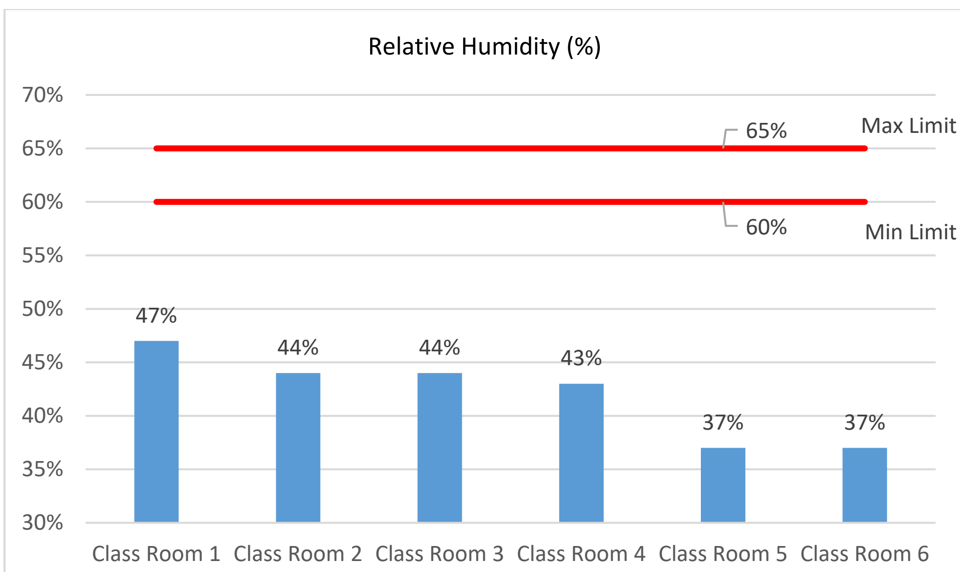

Figure 4. Relative humidity (%) in classrooms compared with the recommended minimum (60%) and maximum (65%) limits.

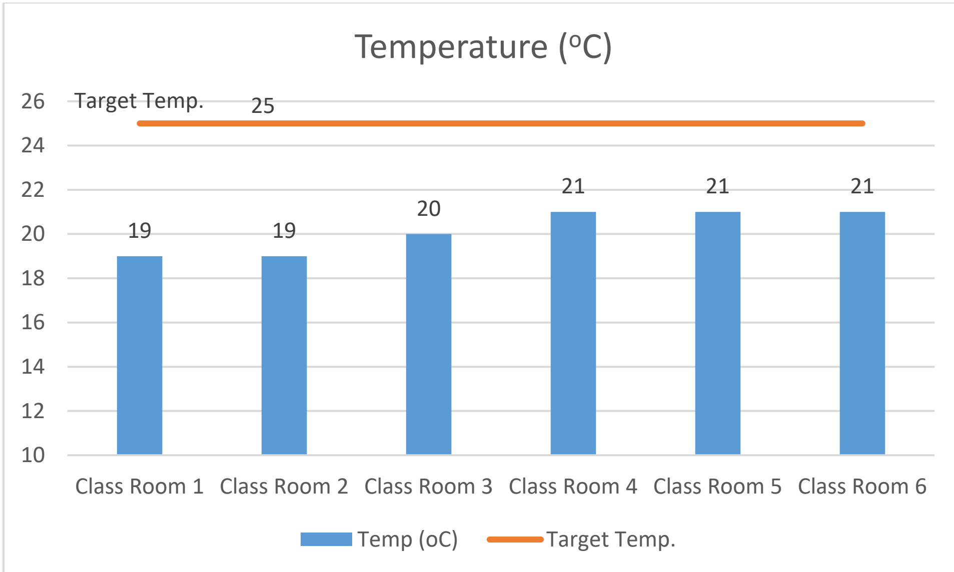

Figure 5. Measured classroom temperatures (°C) compared with the recommended target temperature of 25 °C.

Figure 5 presents the measured indoor temperatures across the six classrooms, with values ranging from 19 °C to 21 °C. All measured temperatures fall below the recommended target temperature of 25 °C, indicating cooler-than-optimal thermal conditions in the classrooms. While these temperatures remain within a tolerable range for occupancy, sustained exposure to lower indoor temperatures may influence thermal comfort and student concentration, particularly during extended instructional periods (Table 1).

Table 1. Data Collection on 02/23/2026

Parameters		Classrooms 1	2	3	4	5	6	Mean	SD	Recommended Range
Noise (dBA)		44	44	45	42	47	47	44.8	1.9	35-40 dB, < 75 dB ANSI (2010).
Air Quality (CO_2 ppm)		563	644	554	513	448	448	528.3	75.3	< 1000 ppm (Ideal: 800 ppm) Sima, *et al.* (2020).
Relative Humidity (%)		47%	44%	44%	43%	37%	37%	0.4	0.0	60% – 65% RH. Zhang *et al.* (2024)
Temperature (°C)		19	19	20	21	21	21	20.2	1.0	25 °C ± 0.5 °C. Zhang *et al.* (2024)
Reflectivity	Columns	52%	47%	47%	47%	47%	47%	0.5	0.0	Ceiling: 80% / Walls: 50-60% Barrett, P., *et al.* (2015).
	Purple Walls	40%	40%	40%	40%	40%	40%	0.4	0.0	
	Ceiling	80%	80%	80%	80%	80%	80%	0.8	0.0	
Color Temp (K)	Middle	2500	4000	3800	4000	3800	3800	3650	572	4000K – 5000K Barrett, P., *et al.* (2015). light
	Near Window	3200	5500	5500	5500	6500	6500	5450	1206	
Luminance (Lux) in different spots		24	42	550	430	446	340	324.1	190.1	300 – 500 lux Zeng, *et al.* (2024)
		33	42	490	490	350	414			
		40	41	290	540	315	350			
		100	209	590	670	208	485			
		92	181	530	560	421	431			
		38	335	437	460	444	468			
		64	126	520	480	446	500			
		24		426	464		330			

	45		424	430					
	102		260						
Light/ Light fixture	LED bulbs on stands	Fluorescent tube lights on ceiling, covered fixture							LED panels Mott, M. S., *et al.* (2012)
Wall color	While columns, light purple walls, white textured ceiling								Cool Tones (Blue/Green) Barrett, P., *et al.* (2015).
Window Condition	Mostly Covered with blinds				Mostly open with light white curtains				58.41% – 62.24% WWR (Zhang *et al.*, 2024)
Time	11:20	11:45	11:50	12:00	12:20	12:40			

Surface reflectivity measurements are presented in Figure 6 and summarized in Table 1. Wall reflectivity values ranged from 47% to 52% for columns and approximately 40% for purple walls, slightly below the recommended range of 50–60%. In contrast, ceiling reflectivity remained consistent at 78% across all classrooms, aligning with recommended value of 80% for effective light distribution and glare control.

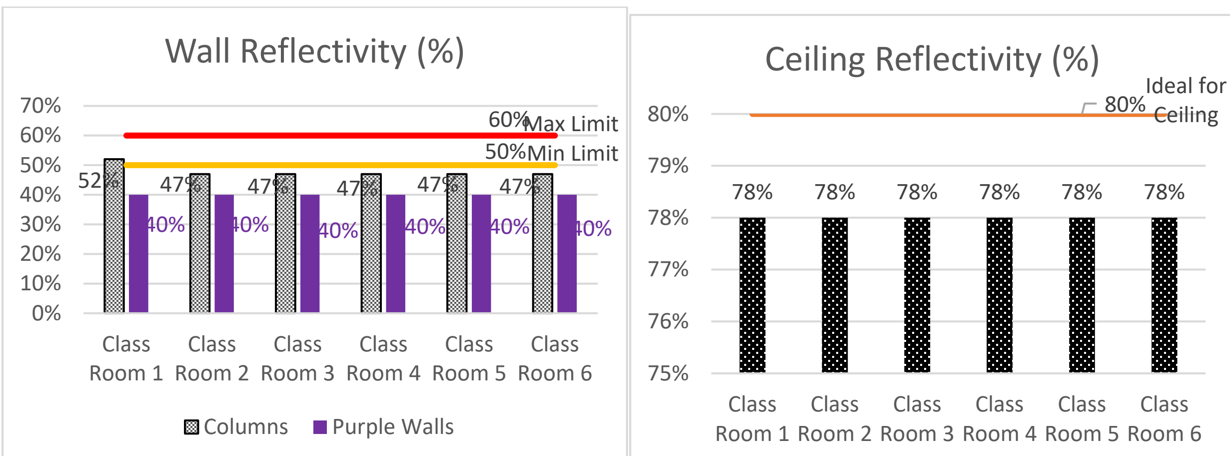

Figure 6. Wall and ceiling reflectivity (%) in classrooms relative to recommended limits for walls (50–60%) and the ideal ceiling reflectivity (80%).

Figure 7 compares light color temperature measured at the center of classrooms and near windows. As shown in Table 1, center-zone values ranged from 2500 K to 4000 K, while near-window measurements increased up to 6500 K, exceeding the recommended upper limit of 5000 K in some classrooms. This spatial variation highlights the strong influence of daylight on color temperature distribution within the learning spaces.

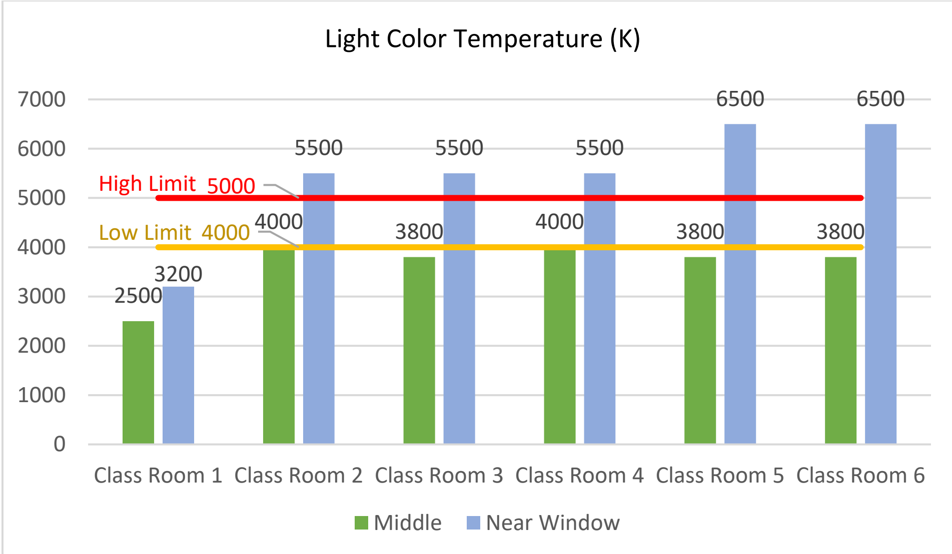

Figure 7. Classroom light color temperature (K) measured at the room center and near windows compared with the recommended range of 4000–5000 K.

Illumination levels measured at multiple locations within each classroom are presented in Figure 8, with values ranging from as low as 24 lux to as high as 670 lux. As summarized in Table 1, several measurement points fell below the recommended minimum of 300 lux, while others exceeded the upper limit of 500 lux, indicating non-uniform lighting conditions. These findings suggest that although average lighting levels may be acceptable in some areas, significant spatial variability exists, which may impact visual comfort and task performance.

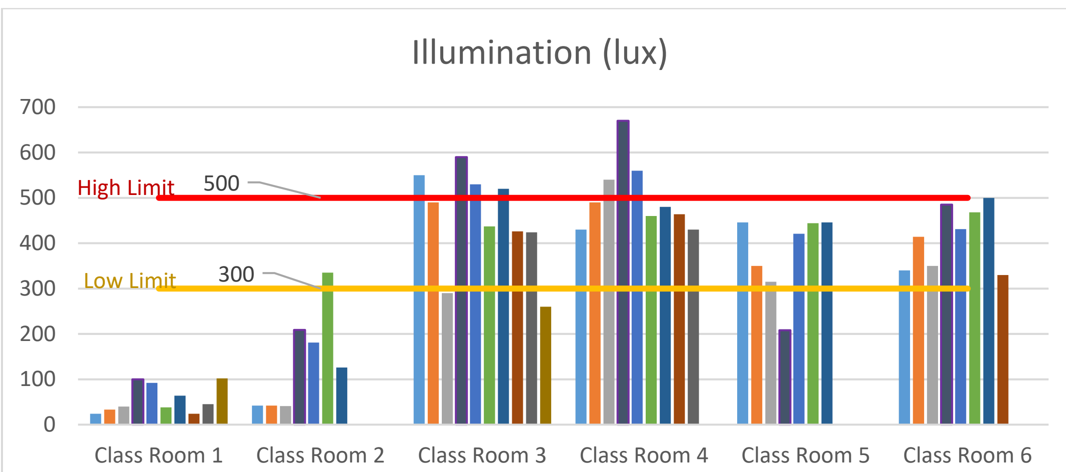

Figure 8. Classroom illumination levels (lux) across measurement points compared with the recommended range of 300–500 lux.

4. Discussion

This study evaluated key environmental parameters in elementary school classrooms in North Louisiana and compared measured values with recommended standards identified in the literature. The findings reveal that while several parameters meet or closely align with established guidelines, others show deviations that may influence student comfort, health, and learning performance.

Acoustic conditions across all classrooms were within acceptable limits, with measured noise levels well below the maximum threshold. This suggests that background noise is unlikely to be a significant barrier to concentration or verbal communication. Similarly, indoor air quality, assessed through CO_2 concentrations, remained below both ideal and maximum recommended limits, indicating adequate ventilation. Given the documented links between elevated CO_2 levels and reduced cognitive performance, the observed values suggest favorable conditions for maintaining student alertness and academic engagement.

In contrast, relative humidity levels were consistently below the recommended comfort range. While low humidity does not immediately compromise health, prolonged exposure may lead to discomfort, dry eyes, and irritation of the respiratory system, particularly in young children. When combined with Louisiana's high outdoor humidity and seasonal allergen exposure, these findings highlight the need for improved humidity regulation to support occupant comfort and well-being.

Thermal conditions also deviated from recommended targets, with classroom temperatures ranging from 19 °C to 21 °C, below the suggested optimal value of 25 °C. Cooler indoor temperatures may be perceived as uncomfortable by some occupants and can influence attention, productivity, and overall satisfaction. These results suggest that thermal setpoints may need adjustment to better support learning activities, especially during extended classroom occupancy.

Lighting-related parameters exhibited the greatest variability across classrooms. Ceiling reflectivity met ideal recommendations, supporting effective light diffusion; however, wall reflectivity values were slightly below recommended ranges. Lower wall reflectance may reduce lighting efficiency and contribute to uneven illumination. Additionally, light color temperature showed substantial spatial variation, particularly near windows, where values exceeded recommended upper limits due to daylight influence. While higher color temperatures can enhance alertness, excessive variation within a single classroom may result in visual discomfort and inconsistent learning conditions.

Illuminance measurements further revealed non-uniform lighting distribution, with several locations falling below the minimum recommended level and others exceeding the upper limit. Such variability may negatively affect visual comfort, task performance, and sustained attention. These findings underscore the importance of integrated lighting design strategies that consider fixture placement, daylight control, surface reflectivity, and adaptive lighting systems to achieve consistent and comfortable illumination.

Overall, the results indicate that while baseline classroom environmental conditions in North Louisiana are generally acceptable, targeted improvements, particularly in humidity control, thermal regulation, wall reflectivity, lighting uniformity, and color temperature balance, could significantly enhance classroom comfort and learning effectiveness.

5. Conclusion

This study provides a comprehensive assessment of indoor environmental quality (IEQ) conditions in elementary school classrooms in North Louisiana, addressing a notable gap in the existing literature. By combining a detailed literature review with field measurements, the research evaluated key environmental parameters including noise, indoor air quality, temperature, humidity, lighting characteristics, surface reflectivity, and window conditions.

The findings indicate that indoor air quality generally met recommended standards, while several environmental parameters deviated from recommended ranges. Noise levels exceeded recommended acoustic comfort ranges, relative humidity and temperature were below recommended levels, and variations were observed in wall reflectivity, illumination uniformity, and color temperature distribution. These deviations have the potential to affect visual comfort, thermal comfort, attention, and overall learning conditions. Given North Louisiana's humid subtropical climate, characterized by high humidity, intense sunlight, elevated UV exposure, seasonal allergens, and mold-related concerns, the results underscore the importance of localized environmental assessments rather than relying solely on generalized standards developed for other climatic regions.

A key limitation of this study is that data were collected from only one laboratory school. Although the school provided a valuable setting for preliminary investigation, its open-design learning concept, university affiliation, and architectural features may not be representative of typical elementary schools in North Louisiana. Consequently, the findings should be interpreted as exploratory and should not be generalized to all regional school environments without further investigation.

Future studies should include a larger and more diverse sample of schools, evaluate seasonal variations in environmental conditions, and examine direct relationships between classroom environmental parameters and student learning outcomes. Based on the findings of this study, several practical recommendations are proposed for schools in North Louisiana: (1) implement adaptive lighting systems and daylight-control strategies to improve illumination uniformity and regulate color temperature; (2) improve HVAC operation and monitoring to maintain appropriate temperature and humidity levels while minimizing mold growth and allergen accumulation; (3) use wall and surface finishes with reflectivity values aligned with recommended standards to enhance lighting effectiveness; and (4) establish periodic IEQ assessments to support data-driven maintenance and facility management decisions. These targeted interventions can help create healthier, more comfortable, and more effective learning environments for elementary school students in the region.

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