



Impact of Classroom Design Elements on Student Performance: Color, Lighting and Environment Conditions

Naomi Lee

Abstract

Classroom design has frequently been viewed in the background when compared to factors like teacher quality and curriculum design, but the physical space can easily shape how students feel and function during the school day. The literature review herein explores the impact of specific classroom design elements—most notably color and the use of natural versus artificial light—on how students are able to learn and participate. Related environmental variables, such as ventilation, temperature, indoor-air quality, furniture, natural views, and spatial arrangement, are also addressed. Search criteria include literature published after 1990 and include peer-reviewed journal articles, systematic reviews, conference papers, and one graduate thesis. In summary, study after study indicates that classroom design can impact students via several interrelated pathways. Well-balanced colors make classrooms feel organized and comfortable, while too much visual stimuli may lead to distraction. Natural light can be related to improved academic performance and mood; however, poorly directed light can cause visual discomfort. Properly adjusted artificial light, too, can support student learning, if utilized properly. Ultimately, students may work and learn more effectively in environments that are within a comfortable range and where the air quality is good. While classroom design cannot replace quality teachers, school funding or a strong student support structure, it can be responsible for either blocking or facilitating learning. The best design is not one size fits all; rather, it is the design that is adaptive and responsive.

Introduction

Students spend many hours each day inside classroom walls. For a majority of these students, school represents their most important learning site—a place to learn how to read, write, take a test, cooperate, and practice the habits that they will apply later in their careers and personal lives. Because most learning happens inside, classroom design has a larger impact than you might think. The colors of the walls, the natural light, the artificial lights, and even the view out of a window can all play a role in the student experience. Additionally, many people think of classroom design as solely an aesthetic issue, resulting in schools just repainting or adding decorations simply to make a classroom look more appealing. However, classroom design is more than a purely visual issue. The same room can determine whether a student feels sleepy and distracted, or comfortable and engaged, based on factors like air quality, temperature, ventilation, or organization. These differences are not always obvious but can add up over many hours per day and for many years.



One major part of the visual design of a classroom is the use of color. Bright, busy, colorful classrooms filled with countless colorful posters, bulletin boards, labels, and students' work on the walls could create an active and positive atmosphere but could just as easily confuse them and leave them wondering what on earth to focus on. Conversely, just a bare, blank room can seem boring and depressing. The trick is not to remove color, but to use it deliberately and functionally.

Another crucial aspect of classroom design is lighting. Natural light can contribute to openness, pleasantness, and students' connection with the world outside the classroom. However, it can also lead to glare, uneven illumination, or unwanted heat if not managed carefully. The artificial lights that are necessary where natural light is insufficient can also impact student functioning differently based on intensity and color temperature. The lighting level for a silent reading might make or break the following classroom discussion or group activity.

Less tangible elements of the classroom environment, such as ventilation, indoor air quality, and temperature, may contribute to alertness or fatigue, while furniture and the layout of the room can make students feel more or less cramped and enable or impede movement and flexibility. Views of nature outside can also decrease stress levels in the classroom. These elements tend to influence each other, so it is often difficult to isolate a single design factor as the most important.

It is also worth considering the issue of equity in classroom design. Most students do not get to choose the buildings in which they must be educated. Some students attend schools with quality ventilation and lighting systems, up-to-date furniture, and large windows. Others must attend school in aging buildings with poor air circulation, faulty lighting, and old furniture. When a student is already struggling academically or socially, these negative classroom design features can become yet another challenge to overcome.

This paper investigates the relationship between four specific areas of student functioning and classroom design: mood, productivity, attention, and physiological response. I will focus on color and the impact of natural vs. artificial light on student performance but also touch upon the role of ventilation, temperature, indoor air quality, furniture, windows, and layout. The central claim that will be argued is that classroom design does significantly affect how students feel and perform, but there is not one universal solution to good design. The classroom design that will typically be deemed effective will use well-balanced colors, controllable natural light, adaptable artificial light, comfortable temperature and ventilation, and flexibility in arranging space to meet a diversity of student needs.

Methodology

This paper employs a qualitative, literature review approach rather than carrying out original experimentation; furthermore, it compares and relates findings of various studies related to the classroom environment and student outcomes. It attempts to discern common themes and patterns among the studies as well as recognize that not all studies lead to neat conclusions.

Only studies published after 1990 were included. The literature selected was used to identify research relating to classroom color, instructional materials, daylight, artificial lighting, temperature, ventilation, indoor air quality, furniture, views to the outdoors, and the design of the space. The student outcomes measured or explored in these studies include mood, productivity, attention and physiological responses; each of these categories were chosen because they address different but inter-related student responses to the classroom.

The age and settings of students in these studies varied; elementary school classrooms were studied, as were college students and adults in the workplace. Because of this variation in population, the results need to be interpreted carefully, and it cannot be assumed that findings about office workers can be applied universally to students in schools, but results from multiple similar studies may inform larger patterns.

I. Mood

Students come to a classroom with pre-established moods, even before any learning takes place. Upon entering a space, a student takes in the colors, lighting, furniture, windows, and the amount of visual “noise” in the environment. While these elements may not seem as important as the actual lesson, they help to frame the space as either serene, welcoming, chaotic, or uncomfortable. The studies reviewed here indicate that the most emotionally supportive classrooms are not the most colorful, exciting, or eye-popping, but rather those that exist in a state of balance.

The color in a space plays a vital role in maintaining balance. Gaines and Curry (2011) point out that color is influential in affecting mood and behavior, particularly if students are to be in the space for extended periods of time. It is not, however, about filling the classroom with more color; intensely bright colors, high contrasts, or crowded displays can overwhelm students who are more sensitive to visual stimuli. Similarly, entirely plain spaces can appear sterile and impersonal. For this reason, softly colored walls that serve as a more neutral foundation with a few purpose-driven pops of color are more effective than extremes. This principle extends to instructional materials. Amarin and Al-Saleh (2020) suggest that color is effective when it allows students’ ability to distinguish between separate ideas, identify patterns, and grasp importance. For example, color-coding can help students differentiate categories in a diagram or understand the relationship between concepts in a presentation slide; however, once color no longer adds

meaning to the content, it loses its effectiveness. Overloading a classroom wall, handout, or presentation with competing colors may result in students having more trouble focusing on what is important. In this way, Amarin and Al-Saleh's findings connect well with Gaines and Curry's, indicating that color is most beneficial when it promotes order rather than chaos.

In addition to color, light is also crucial in changing the impact of color and the room itself. Küller et al. (2006) observed a connection between indoor light and color and mood in a range of workplaces. While these are adults and not K-12 students, the general principle of the connection between these elements is useful for a classroom. The same color that seems calming under natural light might appear harsh under artificial fluorescent lighting; the neutral color that is welcoming during the daytime might be dark or dreary under low lighting conditions. Küller et al. (2006) also recognized that human responses vary, which may explain why there is no single ideal palette.

A student's mood can even be affected by what they can see through the windows of the classroom. Benfield et al. (2015) provided students in a similar college writing class with two rooms: one that overlooked nature, the other that faced a concrete wall. Students in the room that overlooked nature were happier and achieved higher grades on the final. While Benfield et al. do not claim that all students are guaranteed to perform better with a nice view, they do suggest that windows do more than simply bring light into the space; they can also provide mental relief from working indoors for extended periods of time.

It becomes clear from analyzing each element that a classroom's mood is the sum of all its parts. Mohammed and Mohammed (2020) explored the relationships between room dimensions, ceiling height, furniture, color of walls, and shape of architecture in creating a sense of psychological stability in university spaces. It appears that people do, indeed, interact with a room as a whole; the room may contain a pleasant color, but its potential benefits can be nullified by the feeling of a cramped space or uncomfortable furniture. Likewise, the calming effect of a large window may be offset by uncomfortable levels of glare or heat in the room.

This need for the elements of a classroom to work in harmony becomes increasingly important when considering the diversity of students. Gaines and Curry (2011) found that students who are more sensitive to their environment's stimuli may have stronger reactions to intensely colored environments, chaotic visual spaces, or bright lighting. Washington (2024) similarly highlighted how school architecture impacts student mental health by addressing how not all students respond in the same way and how often they have little control over their classroom spaces. The calm, stimulating environment that is good for one student may be overstimulating and frustrating for another, thus Washington (2024) calls for flexible classroom spaces that accommodate individual student needs.

Overall, the findings of these studies do not support a radical, colorful, or overly designed redesign of the classroom but rather call for a calmer and more intentional approach to learning spaces. Soft colors, limited décor, controlled lighting, and natural elements can contribute to a room's atmosphere and the comfort of the students within it. These elements will not always have a direct impact on students' moods but will help to create a space that is conducive to a positive learning experience.

II. Productivity

Physical spaces also play a role in students' efficiency. While students might still complete a task, a more comfortable classroom would reduce the effort required to do so. Classrooms with poor ventilation, a lack of adequate lighting or a presence of glare can create unnecessary challenges. Throughout a school day, these obstacles can hinder students' working speeds and impact their overall energy levels and readiness to learn.

One finding that clearly emerged from the literature is that productivity relies on multiple classroom features. Barrett et al. (2015) investigated 153 classrooms within 27 schools, examining the learning progress of 3,766 students. Instead of isolating variables, they analyzed the effects of light, temperature, air quality, flexibility, color, complexity and the students' sense of ownership over the learning space. Together, these variables accounted for 16% of the variance in academic progression. While this figure does not rank classroom design higher than teaching (%), curriculum (%) or home life (%), it demonstrates that the physical environment is not merely an aesthetic addition, but part of the learning experience.

More specifically, a closer look at daylight reveals the impact of lighting on productivity. Baloch et al. (2021) assessed the performance of 2,670 students across 12 European countries in reading, mathematics, logic and memory based on the daylighting conditions within their classrooms. The study found a link between students' performance on certain tests and several window-related features of the classroom. Specifically, the correlation between window area and classroom area appeared to influence performance. Their results suggested that the inclusion of natural light does foster students' ability to learn; however, it does not support the idea that greater window sizes are always best. Large windows may cause glare, uneven illumination and excessive heating, therefore creating more difficulties within the learning environment.

A similar finding to that of Baloch et al. (2021) can be seen in Tanner's (2009) work when studying school design in a broader context. Tanner considered daylight, view, movement and circulation patterns to see the impact on students' reading comprehension and their abilities in math, science and language arts. They observed positive correlations between these features and learning. This study is significant in that it places the natural element of light within the context of overall architectural design. In conjunction with factors such as a comfortable, flexible

space that has minimal distractions, a good design of the window area within a classroom has a significant and positive impact on learning. It appears as though both Baloch et al. (2021) and Tanner (2009) agree that not only do windows matter, but it is imperative that windows are well designed to minimize potential disruption to learning.

The impact of artificial lighting on students' learning efficiency is also relevant, particularly as natural daylight fluctuates throughout the day and may not be available as a source. Mott et al. (2012) compared students' performance under two differing lighting scenarios in their third-grade classrooms, standard lighting conditions, and under a brighter, cooler focus condition. Students in the focus condition performed significantly better on oral reading fluency, improving 36% compared to 17% with standard lighting. However, motivation and attention levels did not show significant differences. These findings, while useful for suggesting that specific lighting might benefit students' working speeds, indicate that simply adding light and heat is not enough to address every aspect of a learning environment, suggesting that brighter, cooler lighting is not always the answer.

These findings have also been observed with regards to temperature and ventilation within a classroom. Wargocki and Wyon (2007) found that students performed quicker on several tasks when the temperature in the classroom was lowered and outdoor air ventilation was increased. It is important to note that an intolerably hot classroom does not have to be the result before learning can be impacted, moderate levels of discomfort may make students slower and less interested in participating and learning. This concept supports the earlier notion that temperature and air quality were considered critical elements of classroom design within Barrett et al.'s (2015) broad model.

Student survey data is perhaps the most insightful in this regard. Adewale et al. (2021) examined architecture students' responses and found that students were aware of how lighting, ventilation, furniture, the acoustic environment, and facilities impacts their concentration and comfort level. Despite their awareness, no statistically significant correlation was found between these design features and students' grade-point averages. This does not mean that these features don't impact student performance, as it may be that other more influential factors such as teaching and subject matter influence grades far more profoundly and the student may still feel the impact of the room despite earning good grades.

A similar student survey was conducted by Sholanke et al. (2022) within university academic buildings that evaluated students' and lecturers' experience with comfort. Poor indoor-air quality was one of the most frequently identified factors negatively affecting students' comfort, along with lighting and ventilation. These findings make sense considering Wargocki and Wyon's (2007) results; it is likely that students are not directly thinking about ventilation as a factor affecting their performance but their body's reaction to it certainly is. These student

surveys reinforce Wargocki and Wyo's (2007) conclusion and suggest that comfort plays a foundational role in the student's ability to be productive.

In summary, the research on productivity in classrooms suggests that simply optimizing one factor such as the brightness of a classroom is not the goal. Instead, productive classrooms are designed with students' well being in mind. Well-designed windows, sufficient lighting, proper ventilation and comfortable temperatures are all necessary for students to thrive, and once these features are adequate, the physical environment no longer serves as an impediment to learning.

III. Attention

Attention is one of the most obvious effects of classroom design on student learning. Every student must constantly choose what to pay attention to and what to ignore. Students must hear instructions and follow them, look at and comprehend text, engage with problems, and filter out distractions. When a classroom is inherently noisy and distracting, students must invest cognitive energy to manage their environment before they can fully focus on instruction.

A useful way to categorize some of these problems comes from Llorens-Gmez et al. (2022). Their systematic review looks at learning space factors in attention and memory such as lighting, color, temperature, sound, room dimensions, and layout. They argue that these factors are not independent but are interconnected and should not be thought of as isolated problems. The bright glare coming from the window is problematic, and this problem is compounded by a messy wall of visuals and by noises from outside that compete for the students' focus. Even though the light, colors, and sound may seem like minor irritations individually, when combined they can significantly hinder students' attention.

One design element with a strong influence on attention is color. Gaines and Curry (2011) claim color can draw students toward important details or specific zones within the classroom, especially when utilized to highlight specific materials or define areas. Nevertheless, color in the classroom has limitations in drawing students' attention because the stimulation can become overwhelming for the student. A similar effect occurs with instructional aids where Amarin and Al-Saleh (2020) describe how color can be used to organize information into different groups or draw attention toward the importance of a single item but when too many things in the classroom vie for the students' attention, color becomes counterproductive. Together these two studies indicate that the intention is not to make the classroom devoid of visuals but to employ them to help the students identify where to direct their attention.

Lighting is another factor with a clear relationship to attention. Mott et al. (2012) found improved reading fluency when students were bathed in cool, bright artificial lighting but did not

find significant effects in student concentration or motivation. That implies the positive impact on learning could have been task specific rather than solely attention boosting. Baloch et al. (2021) further elaborate on the influence of lighting, stating that learning and daylight performance are influenced by room proportions, size of window opening, amount of shading, and placement of lights. Daylighting can be an excellent attention enhancer, but sunlight can become an impediment to student attention if it causes glare or excessive heat.

The physical arrangement of the classroom has a direct impact on what and who students focus on. Barrett et al. (2015) suggest that flexibility and complexity are key in well-designed classrooms. Too little complexity and a student will quickly become bored, while too much could also hinder attention; effective learning spaces offer a level of complexity that keeps the students stimulated. Layouts should also be flexible and be able to accommodate different kinds of learning; for example, writing may need a different layout than group work or whole class discussions. Flexible furniture that can be easily rearranged and designated areas for various types of learning activities support these changing needs.

Washington (2024) points out the benefit of flexibility when working with students with diverse sensory and emotional needs. Some students work best within their surroundings but may need to be shielded from visual overstimulation by less visual aids and a quieter space in general while others can learn in a visually busy, collaborative space. Learning may occur successfully with a bit of noise and activity but these can also distract a students who need a less visually or aurally demanding space to focus on learning. Gaines and Curry (2011) make a similar claim when discussing inclusive classrooms and how overstimulation might impact student learning differently across the classroom population.

Students' perceptions of the classroom environment strongly support the idea that students will respond positively when they do not have to deal with unnecessary classroom distractions. Adewale et al. (2021) determined that attention was correlated with factors like lighting, ventilation, furniture, acoustics, and the availability of facilities. Similarly, Sholanke et al. (2022) found correlations between students' sense of comfort in their learning environment and their comfort with the lighting, ventilation, air quality, and sound in the room. These findings support the idea that a student's ability to attend well is not solely reliant upon self-discipline or inherent motivation but is heavily impacted by the design of the classroom environment, as Llorens-Gomez et al. (2022) claim cognition is to some degree dependent on environment.

Effective learning environments that foster student attention will be organized yet visually stimulating and appropriately lighted, heated, ventilated, and furnished. This can be achieved without eliminating every potential distraction from the classroom environment; instead, thoughtful and functional design will ensure that instruction takes precedence over classroom noise and visual complexity.

IV. Physiological Effects

The classroom environment can also cause physical reactions in students. It is easy to neglect this aspect of the problem as its effects are not always dramatic. A student may not immediately identify a stuffy classroom, glares from windows, high temperatures or over-stimulation as a reason for his or her difficulty concentrating. Over the course of the day, small physical discomforts may accumulate, resulting in fatigue, headaches, and reduced alertness.

Lighting is the most evident example of this, impacting students' visibility and their body's circadian rhythms. Baloch et al. (2021) not only provide evidence of daylighting conditions impacting student performance but also reveal why abundant sunlight must be controlled carefully; insufficient daylight can lead to eyestrain and tiredness, whereas excessive direct sunlight may cause glare and excessive heat. Window design is vital in terms of size, placement, glazing and shading to ensure appropriate levels of beneficial daylight and the avoidance of detrimental levels of glare and heat. It is important to optimize daylighting not necessarily to maximize amounts of daylight, but to achieve beneficial levels without compromising comfort and causing glare.

Artificial lighting can complement a lack of appropriate daylight. Mott et al. (2012) describe the impact of brightness levels and color temperature of artificial lighting on students' performance on particular tasks and demonstrate the need for a dynamic and adaptable system of lighting. They highlight how brightness levels can influence concentration and work processes and suggest bright and cool lighting for tasks like reading or independent work but indicate the inadequacy of permanent lighting for all tasks and all parts of the school day. Adjustable systems are therefore a sensible alternative to fixed lighting.

Air quality and temperature have as strong, if not stronger, impact on students' performance although they are less apparent. Wargocki and Wyon (2007) provide evidence that schoolwork was completed more quickly in cool classrooms and with higher ventilation rates (outdoor-air supply). They demonstrate that students' performance drops well before they are conscious that the classroom is even slightly warm and/or not ventilated well enough, potentially leading students to feel sluggish and thereby under-perform due to their environment, even when they may not realize it is contributing.

Sholanke et al. (2022) reiterate the importance of the physical classroom by focusing on students' and lecturers' perception of academic buildings. Both identified lighting, air quality, sound, and ventilation as key elements of comfortable and conducive academic building conditions. One key reason for occupants of the studied academic buildings feeling dissatisfied

with their classrooms was the air quality. Their study further corroborates Wargocki and Wyon's (2007) finding, indicating that students may underperform when the air quality of their learning environment is poor, thus the physical conditions of the classroom are more than just a matter of comfort- they can directly impact students' learning capabilities.

Gaines and Curry (2011) suggest that certain design features such as high saturations in colors, strong contrasts and the use of too many visual displays may overstimulate students, particularly those with sensory needs such as sensitivities to brightly lit areas, glare, clutter, or vibrant colors. A student with sensory sensitivities would be able to understand a given learning task from their instructor far easier if presented with controlled colors, a concept supported by Amarin and Al-Saleh (2020), where color has an ability to improve understanding of information, though the use of excessive amounts of it can be exhausting to student learning systems. This does not mean color needs to be excluded altogether from learning environments but it must be controlled effectively so it may serve as an aide to students' learning rather than a barrier.

It is also noted that physical comfort can stem from the interplay of several elements in a classroom, not one discrete feature (Mohammed and Mohammed, 2020). Elements like the room size, height of ceiling, choice of furniture, color design, and lighting scheme can contribute to the perceived feel of a room and when several features are just slightly off, or inadequate, they can combine to produce negative effects that hinder learning and productivity. Students in classrooms with several slightly unfavorable elements (for example, too few desks that can all comfortably be pushed around easily to facilitate cooperative learning), rather than one highly unfavorable element, are at a disadvantage because it is harder for students and teachers to identify which individual elements are negatively impacting them, and to what degree each of those elements is so negatively impacting them.

Llorens-Gomez et al. (2022) offer a perspective that may help students explain why it is harder to work in some classrooms: people's responses to the physical environment can be initiated at a subliminal level, meaning that a student is experiencing a difficulty concentrating before he or she consciously knows the reason; for example, it may be too much glare in the room, a lack of suitable air quality, or a combination of all factors involved in the classroom environment, including the classroom's acoustics and lighting levels. The researchers recommend taking objective measures in conjunction with subjective measurements of classroom environments, because comfort perception only works well when taken alongside physical environmental measurements such as illumination, air quality, temperature, and task completion rate.

Washington (2024) highlights the relevance of physical conditions to equity in education, arguing that students who attend under-resourced schools often learn in outdated, failing, inflexible buildings. These physical conditions only add stress to students' lives, who may

already have additional obstacles to navigate in their educational experience. Therefore, physical comfort should not be an afterthought or an unattainable ideal; rather, it must be addressed to ensure that all students are physically prepared to learn.

Discussion

According to the reviewed documents, several aspects of classroom design can influence students simultaneously. For instance, colors can have a psychological impact on mood and concentration while lighting can affect visual comfort and performance on learning tasks. Productivity can be enhanced by a comfortable thermal environment that contributes to alert students. Furniture, windows, and the arrangement of furniture and objects within the space can have impacts ranging from making the space feel more welcoming, cozy, flexible, or crowded and distracting. Because these features are interrelated, classroom design should not be reduced to one factor; there is no single best answer.

The most consistent theme throughout the studies is that of balance. Although students will not perform poorly in all plain, simple rooms, they should not be adorned in garish colors and accessories without any intention; Gaines and Curry (2011) and Amarin and Al-Saleh (2020) both found that color can be best employed for the purpose of creating structure within the room. Similar to color, natural light can improve student mood and performance, but it also has negative consequences that include glare and heat when not mitigated with the use of blinds or shaded window film. Artificial lighting will also be conducive to students' learning in specific instances and task demands, but one type of light will not be equally effective for the whole day.

Another recurring theme is the importance of flexibility in classroom design. A single classroom space will house activities that vary, ranging from quiet independent work or tests, to group discussions or collaborative projects, to creative artistic endeavors. Adjustable blinds, the ability to move furniture or screens, lighting that can be dimmed and brightened as needed, and dedicated, quieting spaces can help students optimize their learning by configuring the classroom in a way that fits each activity. The benefits of an adaptable space are particularly highlighted by Washington (2024), who argues that the more variation that is provided to students, the better the chances that the classroom can accommodate a diverse range of sensory and emotional needs.

Finally, the studies suggest that schools should be primarily concerned with fundamental student comforts before investing in aesthetic improvements. A more colorful classroom might appear to have been enhanced, but an additional color may do nothing to improve student functioning if the air is stale, if there is glare on students' workspace, or if the room is too hot or too cold. Ventilation and thermal comfort are addressed as key factors by Wargocki and Wyon



(2007), Sholanke et al. (2022), and Adewale et al. (2021). Because thermal comfort impacts all activities during a student's school day it warrants priority.

Several limitations exist within this research base. First, the student populations differ widely between studies. For instance, one researcher examined elementary students, whereas another investigated college-aged students or adult learners. As such, it is not always possible to apply all findings from one study to all learning environments. Younger children may be affected differently than older children, and students with disabilities or sensitivities have different needs from the typical population.

The measured outcomes also vary across studies. Grades or test scores are used to measure the impact of certain environmental variables on students, but reading speed, concentration, the students' own moods and perceptions, and students' sense of comfort are also often employed. Although there is a relationship between these variables, it is important to remember that they do not function interchangeably; students who feel more comfortable may not immediately perform at higher levels academically. Similarly, although a finding of higher test scores may imply that a certain condition is beneficial for student learning, it does not tell the whole story; a student who reads a given passage at a higher speed does not necessarily comprehend that passage at a higher level, or all passages, in the same way.

Additionally, individual environmental factors within classrooms are often not separable; that is, a classroom with large windows may also feature new furniture, be more spacious, and have better ventilation and resources because of a recent renovation. Conversely, schools that can afford modern furniture may also be well-funded enough to maintain a smaller teacher-to-student ratio, offer a wider range of electives, and provide an assortment of other supports to students. Because of this difficulty in disentangling design variables, one cannot be overly confident that there is a direct cause-effect relationship between design and student learning. It is stronger when multiple researchers report consistent patterns.

There are additional limitations. One of them involves the use of student self-report. While student perspectives are valuable to a learning environment, and discomfort can impact students in significant ways throughout the day, it does not necessarily measure how strongly a design feature impacts students academically. Future research might integrate self-reported feelings of comfort and learning with observable tasks such as tests, reading fluency passages, or reaction time tests, or measure physiological changes within students. Llorens-Gomez et al. (2022) suggest that this will be a future focus of the field.

Future research should expand studies beyond just schools with higher resources to examine students and teachers in underfunded K-12 classrooms. The field also needs more research conducted with students with disabilities and sensory sensitivities to document how

these factors impact a wide range of learners. Further evidence of the influence of classroom design on students, in diverse populations and settings, would aid schools in their efforts to create learning environments that provide the best opportunities for students to learn and thrive.

Conclusion

It is important to clarify that the physical learning environment is not the most important component of education and that student learning can still occur in less than ideal spaces; a well-designed classroom cannot compensate for the lack of a competent teacher or the absence of appropriate curriculum and materials. However, it is also important to acknowledge that students should not have to endure hours of daily distraction and discomfort unnecessarily.

The literature demonstrates that classroom design elements such as colors, light levels (natural and artificial), air quality, temperature, layout and design of space, and types of furnishings are all connected in their ability to impact the mood, attention, productivity, and comfort levels of students. There is no single ideal classroom design that can apply to all schools, all ages, and all tasks; rather, design should strike a balance between having too little and too much of a given variable. Colors can be soothing but provide structure and a sense of place. Light should be ample and avoid glare, and artificial lighting should be versatile to suit different tasks throughout the day. A comfortable environment with the proper balance of air circulation, thermal conditions, varied space use, and furniture is what will promote student focus and a positive learning environment.

None of these features will eliminate every learning problem or personal issue students may have, but they can provide support for academic engagement by helping to remove superfluous distractions and barriers to student focus and success. The goal of well-designed classroom space is to support students as they engage in the complex work of learning.

References

Adewale, B., Jegede, F., Okubote, F., & Olagbadegun, M. (2021). Impact of classroom environments on the academic performance of architecture students in Covenant University. IOP Conference Series: Earth and Environmental Science, 665, 012017.

<https://doi.org/10.1088/1755-1315/665/1/012017>

Amarin, N., & Al-Saleh, A. (2020). The effect of color use in designing instructional aids on learners' academic performance. Journal of E-Learning and Knowledge Society, 16(2), 42–50.

<https://doi.org/10.20368/1971-8829/1135246>

Baloch, R. M., Nichole Maesano, C., Christoffersen, J., Mandin, C., Csobod, E., de Oliveira Fernandes, E., Annesi-Maesano, I., & SINPHONIE Consortium. (2021). Daylight and school performance in European schoolchildren. *International Journal of Environmental Research and Public Health*, 18(1), 258. <https://doi.org/10.3390/ijerph18010258>

Barrett, P., Davies, F., Zhang, Y., & Barrett, L. (2015). The impact of classroom design on pupils' learning: Final results of a holistic, multi-level analysis. *Building and Environment*, 89, 118–133. <https://doi.org/10.1016/j.buildenv.2015.02.013>

Benfield, J. A., Rainbolt, G. N., Bell, P. A., & Donovan, G. H. (2015). Classrooms with nature views: Evidence of differing student perceptions and behaviors. *Environment and Behavior*, 47(2), 140–157. <https://doi.org/10.1177/0013916513499583>

Gaines, K. S., & Curry, Z. D. (2011). The inclusive classroom: The effects of color on learning and behavior. *Journal of Family & Consumer Sciences Education*, 29(1), 46–57.

Küller, R., Ballal, S., Laike, T., Mikellides, B., & Tonello, G. (2006). The impact of light and colour on psychological mood: A cross-cultural study of indoor work environments. *Ergonomics*, 49(14), 1496–1507. <https://doi.org/10.1080/00140130600858142>

Llorens-Gámez, M., Higuera-Trujillo, J. L., Sentieri Omarrementeria, C., & Llinares, C. (2022). The impact of the design of learning spaces on attention and memory from a neuroarchitectural approach: A systematic review. *Frontiers of Architectural Research*, 11(3), 542–560. <https://doi.org/10.1016/j.foar.2021.12.002>

Mohammed, N. M., & Mohammed, A. A. (2020). The role of design characteristics of the internal and external spaces of campus to achieve psychological stability: Mosul University campus as case study. *IOP Conference Series: Materials Science and Engineering*, 888, 012001. <https://doi.org/10.1088/1757-899X/888/1/012001>

Mott, M. S., Robinson, D. H., Walden, A., Burnette, J., & Rutherford, A. S. (2012). Illuminating the effects of dynamic lighting on student learning. *SAGE Open*, 2(2), 1–9. <https://doi.org/10.1177/2158244012445585>

Sholanke, A. B., Ekhaese, O. N. E., Faleti, M. O., & Ukaigwe, K. C. (2022). Users' perception of comfort experienced in academic buildings of selected universities in Ogun State, Nigeria. *IOP Conference Series: Earth and Environmental Science*, 1054, 012026. <https://doi.org/10.1088/1755-1315/1054/1/012026>



Tanner, C. K. (2009). Effects of school design on student outcomes. *Journal of Educational Administration*, 47(3), 381–399. <https://doi.org/10.1108/09578230910955809>

Wargocki, P., & Wyon, D. P. (2007). The effects of moderately raised classroom temperatures and classroom ventilation rate on the performance of schoolwork by children. *HVAC&R Research*, 13(2), 193–220. <https://doi.org/10.1080/10789669.2007.10390951>

Washington, A. H. (2024). Disparities within K–12 educational building environments: A framework for designing educational spaces for health and wellbeing in and out of the classroom