Healthy Classroom Lighting—As Fundamental as ABC

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Executive Summary

Growing evidence from neuroscience, chronobiology, and lighting research demonstrates that light does far more than enable vision. It also plays a critical role in regulating alertness, attention, mood, and cognitive performance. These biological responses are primarily driven by blue-sky wavelengths of light that stimulate specialized melanopsin-containing cells in the eye. Today, melanopic equivalent daylight illuminance (m-EDI) provides a standardized way to quantify biologically effective light, with current ANSI/IES RP-46 recommendations calling for at least 250 lux m-EDI during daytime occupied hours. This understanding presents a significant challenge for educational facilities.

Although most classrooms meet conventional visual lighting standards, published studies and field measurements indicate that many provide less than half of the recommended daytime melanopic light needed to support healthy alertness and circadian function. The research shows that simply increasing light output or correlated color temperature (CCT) is rarely an effective solution, as it can increase glare, reduce visual comfort, raise energy consumption, and prompt occupants to close blinds or dim fixtures–ultimately reducing biologically effective light exposure even further.

Blue Sky Light Exposure

*Recommended Daily Exposure is 250 lux m-EDI	
	% of Daily Value*
K-12 School	**42%**
Classrooms	41%
Support Rooms	40%
Front Offices	48%
University	**53%**
Lecture Halls	39%
Libraries	58%
Common Areas	56%
Administration	64%

This paper reviews the current state of lighting in K–12 schools and universities, summarizes the scientific evidence linking healthy blue-sky light with student alertness and learning, and examines why delivering sufficient melanopic light in educational settings has remained difficult. It also presents a practical solution. Award winning SkyView™ Healthy Blue Sky Lighting uses patented Blue Sky Gradient™ technology to deliver the recommended daytime melanopic exposure uniformly throughout classrooms while maintaining low glare, visual comfort, energy efficiency, and a natural lighting experience. Given the extensive time spent indoors in classrooms and offices, SkyView™ lighting represents a powerful, practical approach to satisfying the physiological, behavioral, pedagogical, energy, and fiscal demands of the modern educational environment.

"Education is the movement from darkness to light." – Allan Bloom

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1.0 Healthy Classroom Lighting—As Fundamental as ABC

Every day, millions of students walk into classrooms carrying dreams of what they might become–a scientist, teacher, engineer, artist, or entrepreneur. Yet their ability to focus, interact, and learn depends on more than quality educators, curriculum, and technology. It also depends on one of the most fundamental influences on human performance: quality light.

Extensive research is revealing the connection between blue-sky light, alertness, and cognition, giving educational institutions a powerful new tool to enhance attention, engagement, and academic performance from kindergarten through college.

2.0 Light is Fundamental to Learning

2.1 Light and Performance

Higher light intensities, daylighting, and/or higher blue sky spectral content are well known drivers of mood, focus, alertness, and performance in office and medical spaces. Not surprisingly then, improved classroom illumination is increasingly recognized as an important contributor to student performance and learning.

2.2 K-12 Learning Environments

Research has shown that students in classrooms with greater access to daylight demonstrate significantly higher gains in reading and mathematics achievement compared to students in classrooms with less daylight (Heschong et al. 1999). Daylighting exposure consistently correlates with improved academic performance (Baloch et al. 2021; Lo Verso et al. 2023) including children's wellbeing (Meng et al. 2023). Higher CCT lighting separately or in combination with daylighting results in similar gains in student concentration and cognitive performance including processing, speed, concentration, and memory (Keis et al. 2014; Lekan-Kehinde & Asojo 2021) and oral reading fluency (Mott et al. 2012, 2025). Winter month light levels further exasperate cognitive performance and endurance deficits (Kyta 2020).

2.3 College Learning Environments

Post-secondary environments show similar strong correlations between blue sky light exposure and classroom performance including faster cognitive processing speed and better concentration (Choi et al. 2019; Mogas-Recalde & Palau 2020; Grant et al. 2021). Improvements are also reported correlated with higher alertness and focus in the college classroom (KHanmohammadi et al. 2016) and better performance on complex drawing tasks in architecture (Emara et al. 2024).

3.0 Light and Optimal Time for Academic Performance

Classroom illumination plays a complex role in the timing of academic performance. There seems to be no single "best" time for school studies because performance depends on:

- Age (elementary vs. adolescent)
- Sleep status
- The specific cognitive task being measured
- Circadian phase
- Environmental factors such as light exposure

However, light influences several key factors of student psychophysiology and behavior that affect performance including circadian timing that influences many aspects of motivational state. As a result, research in chronobiology and education has been able to demonstrate that student attention and learning readiness fluctuate predictably throughout the school day (Escribano & Díaz-Morales 2014; Valdez 2019). Attention generally rises through the morning, peaks during the late-morning hours, and declines during the early-afternoon post-lunch period ***(Table 1)***.

Table 1: *Daily Learning Windows*

Time of Day	Typical Cognitive State	Educational Implication
8:00-10:00 am	Rising alertness and attention	Good period for learning and engagement
10:00 am - 12:00 pm	Peak sustained attention and executive function	Often the strongest learning window
1:00-3:00 pm	Post-lunch circadian dip	Reduced alertness and increased mind wandering
3:00 pm onward	Variable; often declining attention	Greater fatigue and lower engagement

Because light is a primary regulator of alertness and circadian function, biologically effective daylighting or blue-sky-enriched lighting can help support student attention during these critical learning windows.

3.1 Adolescents are Biologically Disadvantaged During Early Morning Classes

Puberty often shifts chronotypes and circadian timing. As a result, adolescents, high school and college students are more vulnerable because of sleep deprivation and circadian mistiming (social jetlag) (Minges & Redeker 1016; Dikker et al. 2020; Goldin et al. 2020). This can result in fundamental deficits to learning and associated academic performance including exam grades (Vicario et al. 2025) and GPA (Yeo et al. 2023).

Blue sky light spectra exposure early in the day can help shift circadian daytime earlier and help boost focus and alertness for improved morning period performance. Interestingly, when blue-sky-enriched lamps were installed in student homes, parents reported significant improvements to wake-up, school-time, and bed-time behavior and mood (***Figure 1***; BIOS 2024).

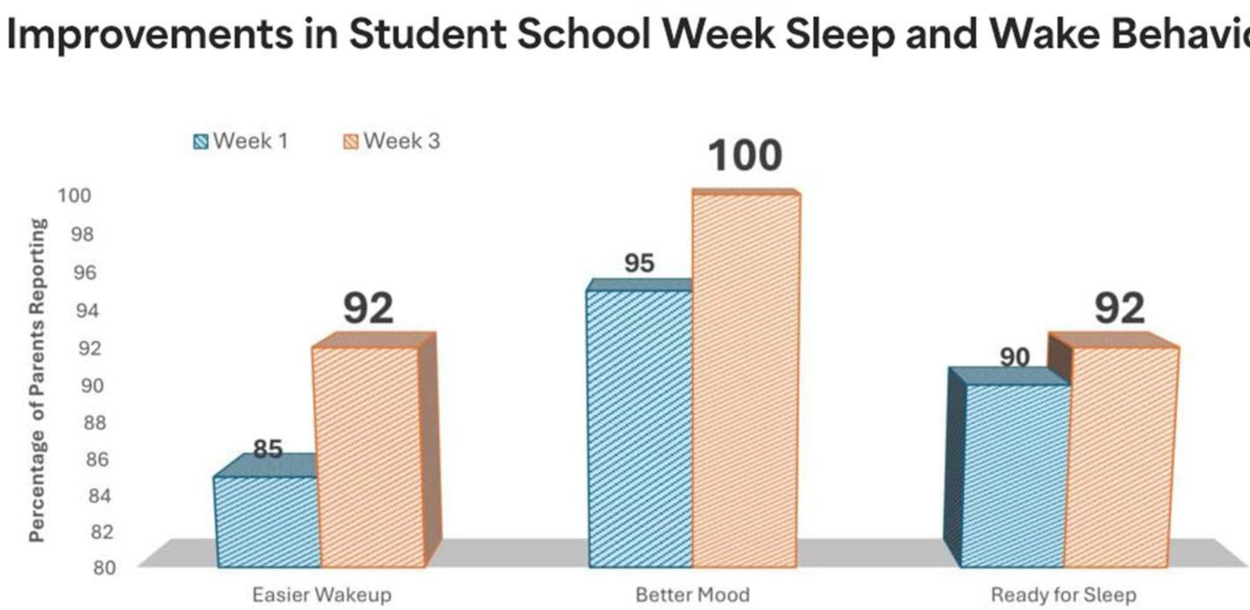


Figure 1. *Results of in-home lighting intervention using SkyView™ blue sky lamps in student's bedrooms. Significant improvements were seen immediately in week 1 with further increases by week 3. Adapted from BIOS Parent Study 2024.*

3.2 Light and Post Lunch Dip

One of the most reproducible findings in circadian science is the "post-lunch dip," a decline in alertness typically occurring between approximately 2 PM and 4 PM. Importantly, this phenomenon is linked to circadian biology and not simply food consumption. Natural, bright, or blue-enriched electric light interventions have been shown to dampen this period of impaired classroom performance (Askaripoor et al. 2019; Zhou et al. 2021).

3.3 Lighting and Problem-Based or Student-Centered Learning

Light exposure has a direct impact on problem-based (PBL) and student-centered (SCL) learning. These demanding learning approaches depend heavily on sustained attention, collaboration, and cognitive flexibility. Studies in educational settings have shown that blue-enriched, daylight-like lighting improves concentration, collaboration, and cognitive performance in students compared with conventional classroom lighting (Mott et al. 2012; Barkmann et al. 2012; Keis et al. 2014). Because active learning approaches require students to generate ideas, solve problems, and interact continuously with peers, classrooms that provide higher levels of biologically effective, blue-sky light may better support the mental stamina and engagement these instructional models demand.

4.0 The Current State of Classroom Lighting

"*What light through yonder window breaks?*" – Shakespeare – It typically isn't enough healthy light throughout the day to optimally support classroom academic performance.

4.1 RP-3-20 Educational Lighting Limitations

ANSI/IES Recommended Practice guidelines for Lighting Educational Facilities state 300-400 Lux @0.76m height AFF with 30-50 Fc on the desk task plane for general classroom lighting. Recommendations are also laid out for various specific facilities and activities. As of 2026, there are no specific recommendations for boosting biologically-relevant light in RP-3. However, the biomedical consensus view on quantifying indoor blue-sky daytime light levels detailed in Brown et al. 2022 was subsequently adopted by ANSI/IES as described in RP-46-25 and is particularly important to educational environments given the impact of higher melanopic light (day and/or electric) on mood, focus, alertness and academic performance. Indeed, there is concern that the lighting practice recommendations do not do enough to encourage the use of human-centric lighting to meet daytime recommendations (Moore-Ede 2026).

4.2 The Generally Poor Levels of Melanopic Light in Classrooms - Published Results

The consensus on blue sky light levels from field and simulation studies shows that there is heterogeneity in healthy light exposure within classrooms, but on average with limited daylighting, levels fall far below the 250 m-EDI needed to support daytime mood, focus, alertness, and circadian function ***(Table 2)***.

Table 2: *Available Melanopic Light (m-EDI) in Classrooms with Limited Daylighting*

Institution Type	Study	Average m-EDI	Range m-EDI	Lighting	Key Finding
University Field Study	Hegde et al. 2025	104.2	33.3 - 297.6	LED & Daylighting	Of 18 classrooms measured, only one met WELL standards even at full brightness and variable daylighting
K-12 Classroom Field Study	Ezpeleta et al. 2021	94	56 - 134	LED	4 classrooms, none met standards with electric lightng only
K-12 Classroom Field & Simulation Study	Lo Verso et al. 2023	52.6	37.4 - 66.3	Fluorescent	3 classrooms, none met standards with electric lighting only
K-12 & University Simulation & Field Study	Hao et al. 2024	112.2	81 - 155	LED & Daylighting	17 classrooms, none met standards on average across entire year
K-12 Field Study	Long & Soler 2025 & unpublished data	135	111 - 173	LED & Daylighting	1 classroom, 20 locations, only 2 met daytime criterion

4.3 Melanopic Light is Food for Thought

Our extensive measurement of melanopic light in classrooms, lecture halls, libraries, front offices and other study rooms supports the published literature in highlighting the limitations of current general illumination to provide students, teachers, and staff adequate biologically-relevant light. Indeed, if we view healthy blue sky light as an essential nutrient, our schools would provide far less than our recommended daily amount.

"The sky is the daily bread of the eyes"
– Ralph Waldo Emerson

Nutrition Facts

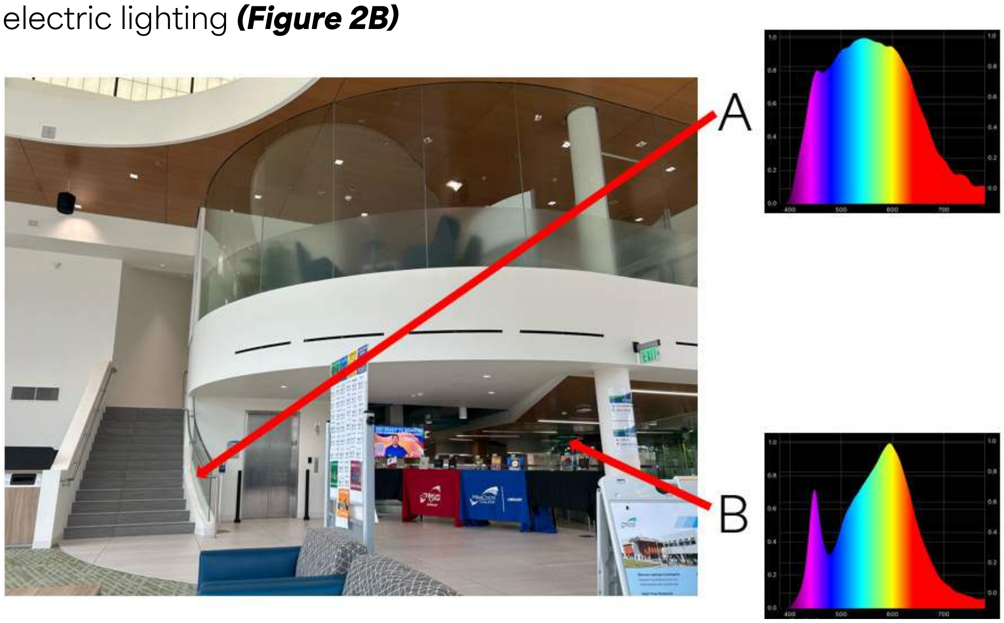
Serving Size: 1 Day in school

Blue-Sky Light Exposure	250
	% of Daily Value*
K-12 School 105lx	**42%**
Classrooms 103lx	**41%**
Support Rooms 122lx	**40%**
Front Offices 120lx	**48%**
University 133lx	**53%**
Lecture Halls 99lx	**39%**
Libraries 145lx	**58%**
Common Areas 139lx	**56%**
Administration 161lux	**64%**

*** Recommended daily exposure in melanopic Equivalent Daylight Illuminance (m-EDI) lx**

4.4 Healthy Light Exposure Often Stops at the Lobby

Modern school and university buildings often have stunning, high design entrances with spacious interiors and abundant natural light. This extravagant use of natural light often diminishes very quickly as you move through the lobby and into the functional halls of the building ***(Figure 2A)***. Blue sky light exposure also diminishes quickly with heavy reliance on electric lighting ***(Figure 2B)***



Horizontal plane illumination: 497 lx

Vertical plane melanopic light: 293 lx m-EDI (117% of blue-sky criterion)

Horizontal plane illumination: 456 lx

Vertical plane melanopic light: 130 lx m-EDI (52% of blue-sky criterion)

Figure 2. *A comparison of general illumination and melanopic light in two locations within a vaulted-ceiling lobby of a university library. Sample location A is in the main lobby while B is 5 meters away in the common reading area. Note the significant drop in blue-sky light between A and B, while the task plane illumination remains relatively constant.*

5.0 The Challenge of Optimizing Biologically-Relevant Light Penetration in Classrooms

Combining day and electric lighting to optimize high-melanopic general illumination in classrooms is often more difficult than in offices because classrooms combine several design constraints that work against delivering sufficient light to students' eyes while maintaining visual comfort, energy efficiency, and instructional effectiveness.

5.1 Daylighting in Classrooms

Daylighting often potentially contributes most of the biologically effective light available to students. Indeed, windows are not only the gold standard for healthy lighting but are preferred places to sit by students when given the choice (Angelaki et al. 2022; Angelaki 2025). However, the limitations of daylighting are well documented and are particularly poignant in educational environments. Daylighting often fails to provide adequate melanopic light because:

- Many classrooms have limited window exposure reducing the window-to-wall ratio (WWR)
- Temporal and spatial heterogeneity of daylighting creates uneven student illumination
- Students have a wider range of light and distraction sensitivity prompting shading or louvering
- Modern educational tech (i.e. projectors, interactive displays, large-format screens, whiteboards, etc.) compete with daylight prompting shading or louvering

Despite the value of natural illumination in classrooms, the effective implementation of daylighting continues to be limited. Indeed, a 2024 EdWeek Research Center Survey of 524 K-12 teachers showed that almost 20% of classrooms had no natural light exposure (14% didn't even have outward facing windows). One in five teachers said they had daylighting between 1-50% of the school day. Only half of the teachers reported having natural light more than 75% of the day, although overall melanopic effectiveness is likely dampened by environmental or structural constraints discussed above (Prothero 2024).

"There are two kinds of light–the glow that illuminates, and the glare that obscures."
–James Thurber

5.2 Glare in Classroom Environments

Students tend to be more sensitive to glare during learning engagements. Glare caused by daylighting has well documented negative consequences in academic performance including math, reading and copying efficiency (Bian et al. 2020; Singh et al. 2020) despite the generally well supported positive correlation between increased classroom illumination and test scores (Heschong 1999; Singh et al. 2020). Strongly side-lit spaces are particularly prone to high contrast, spatial heterogeneity in illumination and glare. Due to the relatively extreme differences in lighting between various seating positions in side-lit classrooms, glare and discomfort models are most predictive if the Daylight Glare Probability (DGP) equations include significantly different components for window and wall zones (Viula et al. 2023).

Such window illuminated classrooms are very common and standard practice in architectural design. The result is often limited use of daylighting in favor of more uniform electric lighting.

5.3 The Impact of Skylights on Classroom Illumination

Skylights, windows, or a combination of both seem like a reasonable approach to providing adequate melanopic into classrooms and various configurations of skylights or high transom windows are utilized in modern classroom design. Indeed, Heschong's (1999) study of several school districts showed an intriguing positive relationship between academic performance and daylighting, window area, and skylight area ***(Figure 3)***.

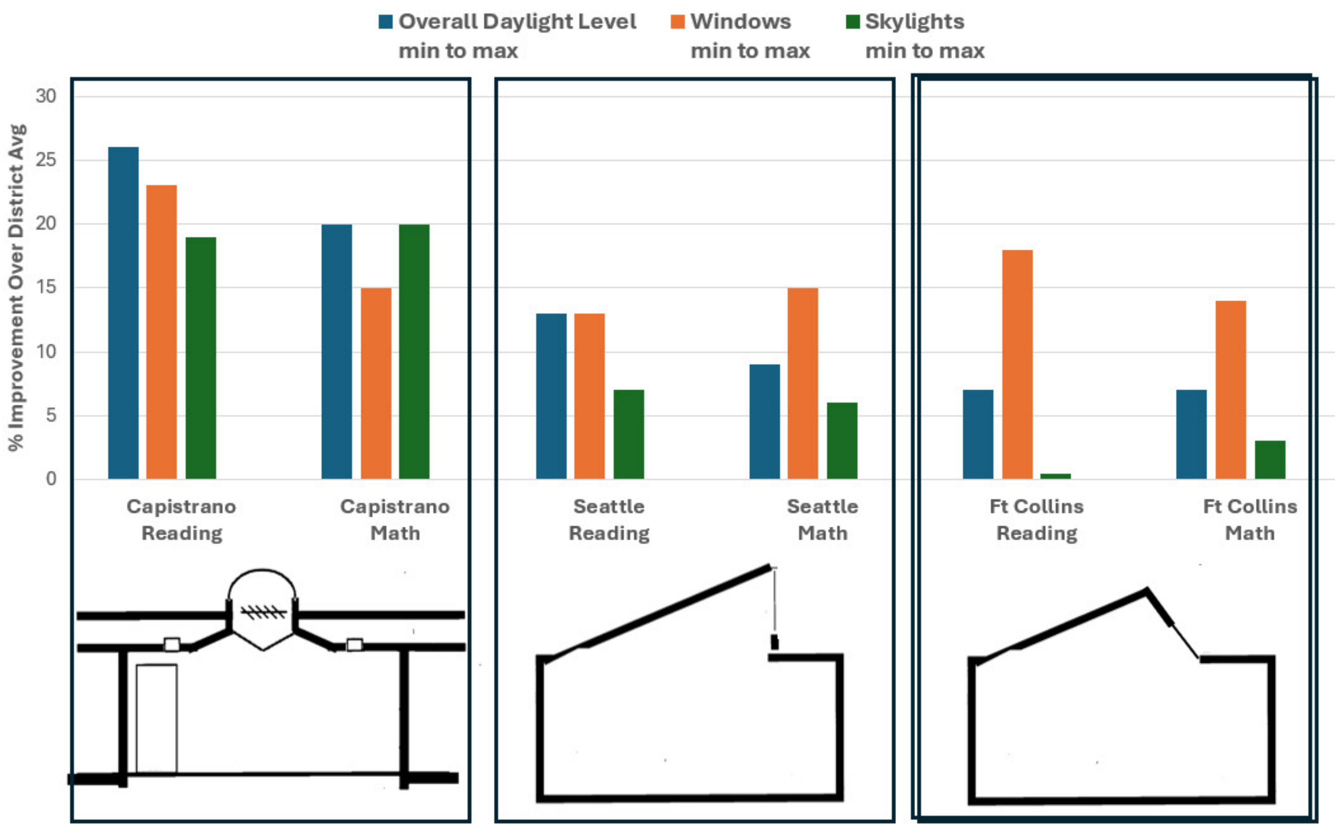
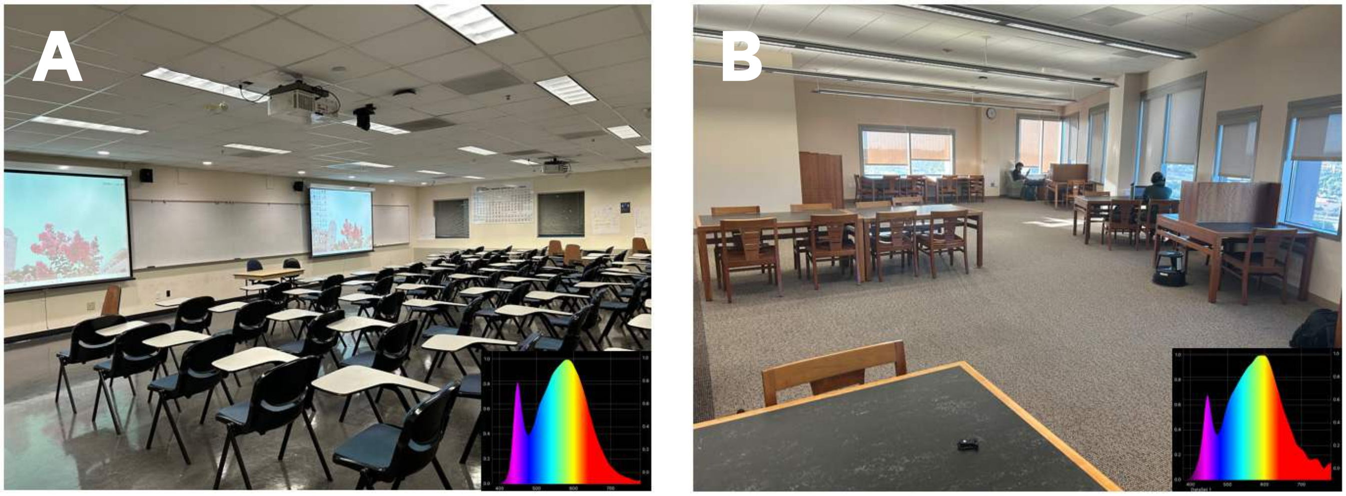


Figure 3. *Comparison of Skylight configurations and classroom academic performance for three school districts. Daylight, window, and skylight measurements are a comparison of minimum value to maximum value. Adapted from Heschong 1999.*

In subsequent analyses and field interviews with teachers, the relationship between skylight exposure and performance and its causation are not as clear (Heschong & Mahone 2003). It seems reasonable that brighter classroom environments correlate to better student behavior and outcomes. They are clearly preferred by students, teachers, and architects. However, increased classroom daylighting almost always comes with increased glare that leads to countermeasures.

Teachers report challenges with glare, uneven lighting, and thermal issues that result in significant shading or louvering. Heschong et al. found even on a partly sunny winter day in Colorado, 60% of the classrooms in the study district had their shades closed (Heschong et al. 2002). This aligns well with our own field observations in southern California between fall 2025-spring 2026 where we found over 71 % mostly or complete window and skylight shading in K-12 and university classrooms, study areas, and libraries resulting in a substantial loss of blue sky light ***(Figure 4)***. These areas also have window tinting reducing visible light transmission (VLT) by 30-50%.



220 lux task plane
138 lux m-EDI (face plane @ 4ft AFF)
55% of blue sky criterion

801 lux task plane
171 lux m-EDI (face plane @ 4ft AFF)
55% of blue sky criterion

Figure 4. *Typical midday shading of windows in university classrooms **(A)** and library study areas **(B)** resulting in high contribution of LED electric light (see inset SPDs) to the ambient illumination versus daylighting. Note the contrast between the bright task plane illumination and the insufficient melanopic light based on RP-46-25 recommendations for ≥250 lx m-EDI daytime exposure.*

5.4 Light Wells and the Challenge of Blue Sky Line-of-Sight

Light wells, light shelves, tubular daylighting, and window baffles are a popular and effective way to maximize daylighting illumination while minimizing glare (Dahlan & Eissa 2015; Mesloub et al. 2026). The indirect path that light takes into the classroom maintains ample and diffuse illumination providing substantial task plane illumination.

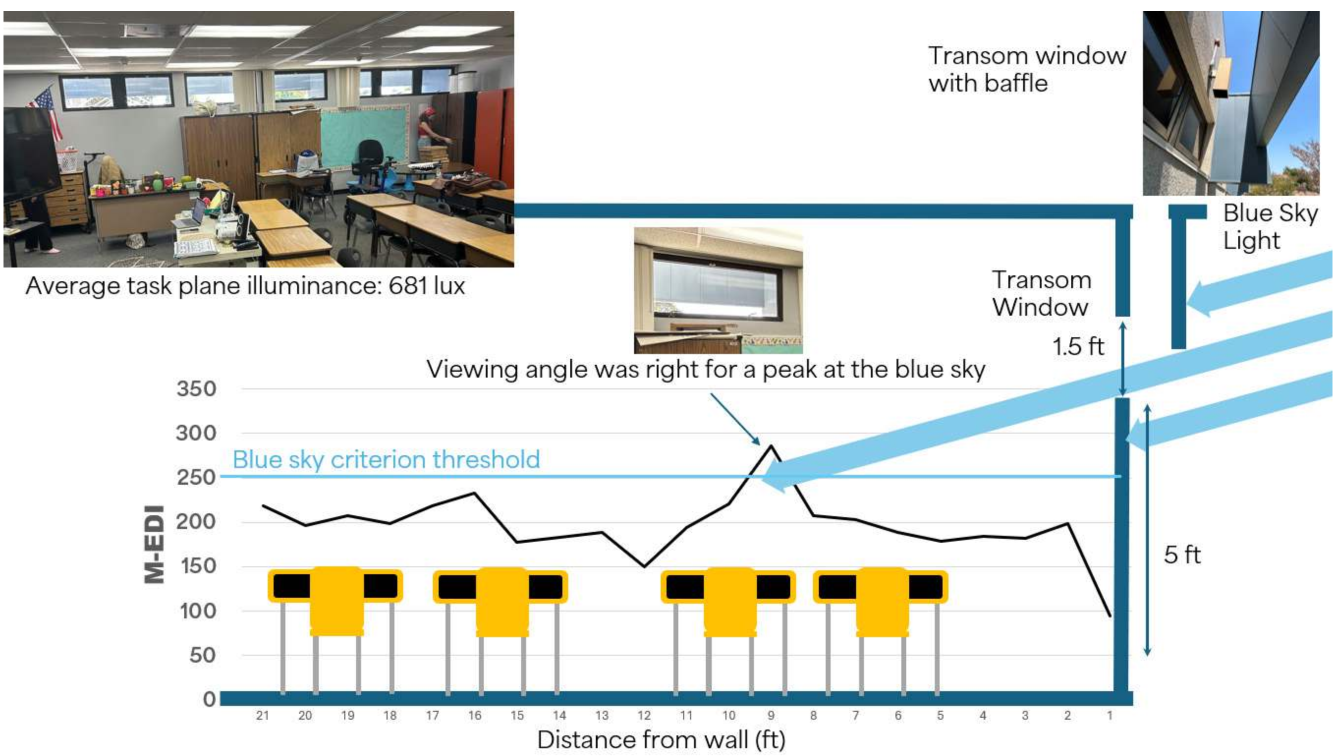


Figure 5. *Results from a study of external light baffles on a classroom transom window. Note the significant loss in melanopic EDI when blue sky was not directly visible to students.*

Significant loss of light intensity through material absorption is typically acceptable, if not preferred, when just considering ambient task plane illumination. However, the amount of blue sky light (cyan peak 490nm) is only a fraction of the overall spectral power distribution meaning that the loss to biologically-relevant melanopic light is significant.

Our research shows that exposure to healthy blue sky light indoors is sensitive to line-of-sight. Simply put: if you can see some blue sky in your view, you are likely getting close to adequate melanopic light as per RP-46-25 recommendations. Light baffling reduces available blue sky light in classrooms and creates significant variation in who receives it often resulting in wide areas of poor student coverage ***(Figure 5)***.

5.5 Classroom Surfaces Impact on Melanopic Light

Classroom blue sky light is also impacted by surface absorption. Classrooms, especially at the elementary level often have darker or more colorful surfaces that impact available melanopic light. In comparisons of incident and reflected light on typical surfaces in classrooms, we found both photopic and melanopic light levels absorbed by as much as 95% ***(Figure 6)***. In published lighting simulations, the effective melanopic light as measured by the ratio of visible to melanopic light: m-DER) is decreased by an average of 22.5% due to absorption of classroom materials (Lo Verso et al. 2023).

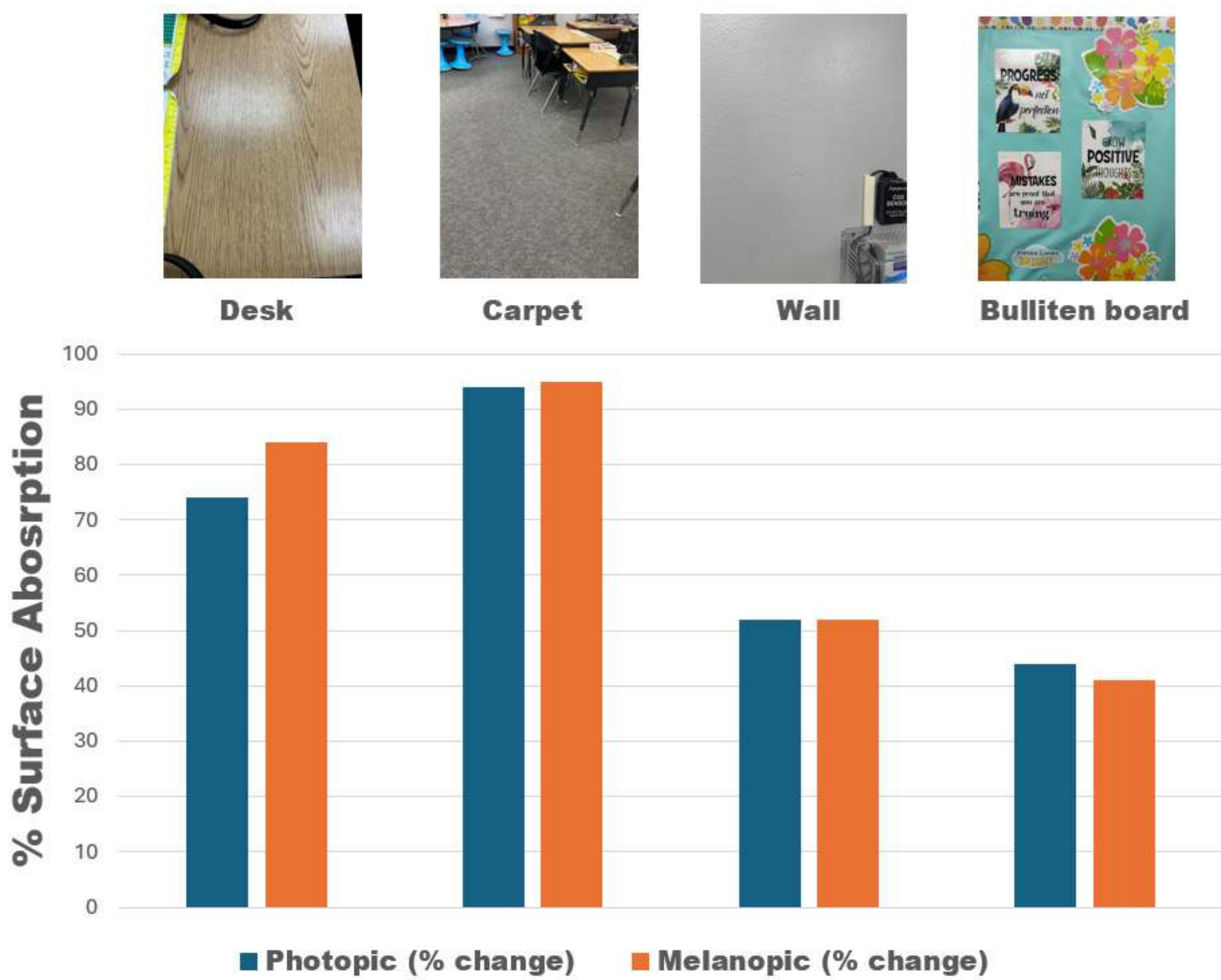


Figure 6. *Absorption of general illumination (photopic) and blue sky light (melanopic EDI) for common classroom surfaces.*

Other common materials of biophilic design such as wood-tone or natural surfaces and plants differentially absorb blue spectra, further decreasing available melanopic light in the classroom. In field measures and simulations, light wood surfaces, typical of student desks significantly dampen melanopic signals below minimum RP-46 criteria regardless of window dimensions or orientation (Acosta et al. 2019).

5.6 The Unique Challenges of Student and Teacher Responses to Classroom Light

The research suggests that students and staff generally value daylight, but only when it remains visually balanced and compatible with learning tools and prolonged focus demands (Aram & Alibaba 2025; García-Fernández & Bonilla 2026). Many classrooms have multiple functions and must accommodate desk and furniture reconfigurations frequently to support various individual and group learning activities. This dynamic nature of the teaching environment makes the heterogeneity caused by daylighting and electric lights particularly distracting for teachers and students. Field observations and interviews reveal that teachers regularly shade or block windows and add colored tinting shades to overhead fixtures to dampen the uneven illumination or glare ***(Figure 7)***.

Figure 7. *K-5 classroom with modified lighting to support diverse learning activities. Desk plane illumination is 735 lx, while vertical plane melanopic EDI is 176 (70% of blue sky criterion).*

Students often choose areas or perform better with more light for reading (Wang et al. 2025) and collaborative activities (Zoubi et al. 2024) but not so for computer work (Fang et al. 2022). Daylighting is often then suppressed in practice and there is a strong need for uniform, higher CCT general illumination in classrooms where the light levels can be independently controlled by the instructor.

6.0 Early Experiments with Blue-Enriched Classroom Lighting

Interest in blue-enriched classroom lighting emerged in the early 2000s as researchers began investigating "full spectrum" light's influence on behavior, alertness, and learning. While early classroom studies demonstrated that blue-enriched lighting could improve concentration, alertness, and cognitive performance, researchers also discovered important limitations. Keis et al. (2014) reported significant improvements in student alertness and cognitive performance under blue-enriched classroom lighting, yet approximately half of the students perceived the environment as excessively bright. Similarly, researchers found that many classrooms suffered from glare and visual discomfort caused by excessive brightness, daylight reflections, and poorly controlled lighting systems (Winterbottom & Wilkins 2009). Later research showed that increasing correlated color temperature alone does not necessarily improve visual comfort, with some students preferring moderate CCT environments over cooler, bluer lighting (Yang & Jeon 2020). Together, these studies suggest that successful circadian lighting design requires more than simply increasing blue light or intensity. An improved approach is needed to deliver biologically effective light to the eye while maintaining visual comfort and minimizing glare.

6.1 Thought on Healthier Classroom Lighting Has Progressed as Follows:

- Phase 1 (1980's-2010): "Daylighting is good but limited"
- Phase 2 (2005–2015): "Blue-enriched lighting or daylighting measurably improve performance."
- Phase 3 (2010–2020): "Raising CCT and brightness can increase blue light but also create comfort issues that must be mitigated or tolerated."
- Phase 4 (2015-2025): "LED color tuning and increased brightness can deliver more blue-enriched light but comfort and energy consumption issues limit the ability to achieve RP-46-25 healthy lighting recommendations for much of the school day"
- Phase 5 (2025-today): "The goal is uniform lighting with high melanopic stimulus delivered efficiently to the eye consistently, without the glare, excessive brightness, and energy penalties associated with earlier approaches."

7.0 SkyView™—The Next Generation in Blue Sky Lighting for Educational Institutions

The next generation of classroom lighting must go beyond illuminating desks to support the biological needs of students and staff while maintaining visual comfort. Demonstrated in field and clinical studies (Soler & Long 2025), SkyView™ by BIOS Lighting provides the healthy blue sky light needed to support mood, focus, alertness, and circadian health.

SkyView™ achieves this through patented Blue Sky Gradient Technology, which delivers biologically-effective blue sky light from high angles directly to the eyes while projecting warmer, lower-angle light onto learning surfaces. This approach helps provide the melanopic stimulus needed for academic performance without the excessive brightness and glare often associated with strong daylighting or traditional, blue-enriched lighting systems. The unique illumination eliminates strong down lighting to reduce harsh shadows improve facial modeling to better support communication, collaboration, and student engagement. The fixtures are simple to install and easily automated or controlled by the teacher.

7.1 Classroom Illumination with SkyView™ Tile versus Standard LED Light

We used the Blue Sky Estimator to model the electric light contribution in an actual K-5 classroom we have previously measured. The 20x30 foot room with 8 foot high ceilings (RCR 2.29) and typical surface reflectances was illuminated with CRI 90 lights that put 340 lux on the target task plane. The Estimated blue sky light (m-EDI) using recessed troffer LED lights at 4500K was 75.8 lux (Figure 8A). This provided only 30.3% of the daytime blue sky criterion that would support mood, focus, and alertness in the classroom. In the same classroom configuration under SkyView™ Tile providing 5300K but with spatial color separation, the result is an estimated 250.6 lux m-EDI that meets the daytime criterion (Figure 8B).

Figure 8A. *Standard LED Lighting*

Estimated V:H Ratio

0.328

Estimated V:H Ratio

0.68

Estimated m-EDI

75.8

% of Daytime Blue Sky Criteria (RP-46-25)

30.3%

Estimated Productivity Loss 10.5% productivity loss

Figure 8B. *SkyView™ Tile Lighting*

Estimated V:H Ratio	0.670
Estimated V:H Ratio	1.10
Estimated m-EDI	250.6
% of Daytime Blue Sky Criteria (RP-46-25)	100.2%
Estimated Productivity Loss	0% productivity loss

8.0 Conclusions on Improved Blue Sky Light in Educational Environments

By working with daylighting to create a more natural balance of light within the classroom, SkyView™ tile and linear pendant is the most practical approach to healthy illumination for all educational spaces and activities. The result is healthy lighting for healthy minds.

SkyView™ Blue Sky Lighting benefits for students, educators, and support staff	
RP-3-20 & RP-46-25 Compliant	Delivers uniform, healthy, general illumination for all classroom and education-related room configurations
Blue Sky Gradient Technology	Provides natural feeling, low glare light for all activities
Delivers 250 m-EDI of Blue Sky Light	Meets daytime healthy light requirements regardless of windows, latitude, season, weather, room orientation or occupant location
Boosted Mood	Fosters better peer and student interactions
Improved Focus	Fosters active listening and engagement
Increased Alertness	Allows better morning period and post-lunch productivity and sustained energy throughout the day
Circadian Rhythm Support	Supports improved sleep and wake timing
Standard Controls	Allows easy intensity adjustments by room occupants for different classroom activities
Energy Efficient	Provides high melanopic light at a low energy usage (0.4W/ft^2) - considerably under energy codes
Practical Solution	Installs as an easy 1:1 replacement tile for existing troffers. Units are low cost and easily maintained.

SkyView™ brings the benefits of a blue sky day indoors to help educational institutions create environments where students and staff can learn, focus, and perform at their best.

"I never get tired of the blue sky"
–Vincent Van Gogh

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