READY, OR NOT?

We know that lighting has the power to significantly affect human health, performance and well-being. But do we know enough today to apply this knowledge wisely in our schools?
OVERVIEW

The lighting industry has enthusiastically moved ahead with lighting solutions for health and well-being targeted to education facilities. Some of these flexible, intelligent lighting solutions intend to recreate elements of our experience of natural lighting and so reap the benefits of maintaining our bodies’ natural circadian cycles. Others enable educators to confidently configure color temperature and light levels to boost alertness, energy and performance.

The argument for embracing these solutions right now is pragmatic: today, most students and teachers spend every day under non-tunable lighting. Like all illumination, these lights have a myriad of effects on human physiology. If a school is preparing to install new lighting, shouldn’t they use what is known to maximize lighting’s beneficial effects, or at the very least, minimize any downsides? And won’t schools that are slow to adopt human-centric lighting risk falling behind those that choose to leverage more advanced lighting solutions?

The counter argument is one of prudence: because our knowledge is incomplete, educators should wait for more evidence before investing in intelligent, color-tunable lighting specifically for its potential impact on people, especially children. One concern is that some of the indicated benefits have yet to be confirmed by large, rigorous, replicable longitudinal studies across various age groups and circumstances. While much is known and readily applied about the optimal visual characteristics of lighting for different cohorts, nonvisual physiological and psychological effects are less well understood.

Those in favor of investing sooner rather than later also point out that a number of highly respected industry organizations have developed well-researched application guidelines and metrics to enable adoption right now, based on what is known.

With all this in mind, we intend this paper to help educators sort through the evidence and anecdotes, facts and opinions to reach an informed answer to the central question of human-centric lighting: Act now - or wait and see?
What We Know

For millions of years, humans woke up, lived, learned and thrived outdoors under the reliable and natural movement of the sun. We thus evolved our circadian cycle – a biological clock exquisitely calibrated to align our physiology to the different phases of a 24-hour day.

But in modern society, people spend over 90 percent of their time indoors, far from natural sunlight. We typically experience too little light in the day and too much at night. Some of the effects created by this mismatch of ambient lighting and our internal clock have long been known. Jet lag is one of the most profound, common – and dreaded – examples. Crossing multiple time zones (especially moving from west to east) leaves us plagued by daytime lethargy and nighttime insomnia for several days until our internal clock resets.

In recent decades, interest in lighting’s effects on humans has trended sharply upward. The advent of LED lighting only added to the impetus. The initial attractions of LED lighting were its dramatic energy savings, longer lifetimes and much lower maintenance costs. But lighting experts and researchers soon realized LED lighting’s greater potential: solid-state technology made it cost-effective to develop intelligent and flexible lighting solutions that could be tuned to different color temperatures, automated to respond to ambient daylight, dimmed in minute increments and configured to express carefully sculpted spectral distributions.
A New Lighting Fundamental

Sunlight was the only significant light source for 99.999% of the time that life has evolved on earth, so natural light’s position as the gold standard is unlikely to change anytime soon.

But now that our industry more fully understands the profound biological, functional and emotional effects lighting has on people, intense interest in the science of lighting is revealing exciting new ways to use the next best thing: artificial lighting that emulates the spectral properties of natural light and the 24-hour cycle of day and night.

Three scientists won the 2017 Nobel Prize in Physiology or Medicine for work uncovering the molecular mechanisms controlling our circadian clock, including light’s powerful role. Their work identified a nonvisual type of photoreceptor in the human eye named intrinsically photosensitive retinal ganglion cells (ipRGCs) which have a different function than rods and cones.

This confirmed decades of previous research suggesting that a circadian rhythm synchronized to natural light helps us feel more energized during the day and sleep better at night, improves our immune system, lowers our stress and even reduces our risk for diseases like diabetes, obesity, cancer and mood disorders.

In contrast, if our circadian rhythm is misaligned, a host of negative consequences can arise, including agitation, chronic fatigue, an inability to concentrate and an increased risk for various diseases.

Many factors are involved in synchronizing our circadian system. Blue (short) wavelengths, perceived as brighter light, are the strongest agent, and blue light plays other roles as well, enhancing alertness and wakefulness, enabling faster reactions and fewer lapses in attention, and contributing to overall better performance of complex visual tasks.
Many lighting solutions on the market now offer automated or manual tuning of correlated color temperature (CCT). This tuning changes the ratio of blue light to the rest of the visible spectrum to mimic the gradual spectral shift of daylight from morning to evening.

Benefits can include:

- Lowered Stress
- Improved Performance of Complex Visual Tasks
- Less Fatigue
- Reduced Depression
- Enhanced Alertness
- Increased Energy
- A Strengthened Immune System
- Improved Sleep
What This Could Mean For Educators

Human-centric lighting has obvious, significant implications for educational facilities, especially classrooms, lecture halls and other learning environments. Around the globe, academic researchers and educators are conducting pilot programs and further research to assess and confirm potential benefits.

To date, the preponderance of evidence indicates that circadian-tuned lighting does confer general benefits such as improved alertness, energy levels and mood support for students, faculty and administrators. Nor do these gains go unnoticed – the evidence also suggests such lighting will improve overall student and teacher satisfaction with their learning and working environments.

What may be the most exciting question has yet to be definitively answered: Does human-centric lighting improve students’ grades and test scores?

The evidence is insufficient to unequivocally make this claim. But ongoing research findings and anecdotal reporting on pilot programs are promising.

In a study with 84 pupils (grade 3, age 7 to 8), oral reading fluency was measured for two kinds of light conditions. Children in the group with optimized lighting started with a lower score and ended with a significantly higher score compared to the children in the control group.4

Dutch investigations have shown that with higher illuminance levels and higher color temperatures (closer to daylight), academic performance improved, while a reduction of light levels and lower color temperature decreased agitation and classroom disturbances during lessons.5

Harnessing A Complex Science

The LED lighting industry has prided itself for increasingly rigorous technical application standards and precisely calculable ROI. But it’s a different kind of challenge to establish similar metrics that involve the complex systems of human physiology, or to quantify intangible benefits like “a better learning environment.”

One issue is that tunable CCT alone is not a sufficient measure to fully recreate sunlight’s effect on human circadian rhythms. For example, a 2018 article published in arc, an international magazine in architectural lighting design, summarized a human-centric lighting workshop with industry leaders who stressed that the most energy-efficient LED lighting produces blue-rich white light similar to the bright light of midday, but has a different spectral power distribution – and therefore would have different biological effects.

At the same time, neuroscientists, biologists, academics and others are continuing research to answer other questions necessary for optimal application: What intensity and color of light should be applied when and where, and for how long? How much should guidelines vary by age, sex and other biological differences? Are there other important nonvisual effects (positive or negative) that we’ve yet to identify?
Underwriters Laboratories recently published the “Design Guideline for Promoting Circadian Entrainment with Light for Day-Active People,” DG 24480, based on the Circadian Stimulus (CS) method developed by Rensselaer Polytechnic Institute’s Lighting Research Center. It relies on the LRC’s CS Calculator, a web-based tool for converting predicted or measured vertical illuminance values into CS metric values.

The WELL Building Institute has also added circadian-supportive lighting to its recommendations, with a spectrum component weighted to ipRGCs called the Equivalent Melanopic Lux (EML). Other potential metrics are now emerging, including a circadian action factor, melanopic sensitivity and melatonin suppression index.

While these competing models and metrics don’t completely overlap, all support the idea that lighting is a main contributor to our circadian systems and that our built environment can play a larger role.

That’s fortunate, as interest continues to surge. LEDs Magazine’s 2020 State of the Industry Survey reported that lighting for health and well-being outscored other niche applications in terms of respondent interest.

THOSE READY TO ADOPT

Whatever it’s called – human-centric lighting, circadian lighting, research-informed human lighting (RIHL), experiential lighting – many experts and lighting manufacturers believe lighting that’s beneficial for humans is now actionable.

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Human differences are vast, and factors that could influence our response to lighting – beyond alignment with a standardized circadian clock – vary tremendously. These factors include not just who we are biologically (age, gender), but where we are, what we’ve been doing, and other independent behavioral and environmental factors.

In a 2019 paper published by the IES called *Circadian Lighting: An Engineer’s Perspective*, Ian Ashdown, a retired senior scientist at SunTracker Technologies, robustly detailed the technical shortcomings of both the CS and EML metrics. He finally concludes that “Regardless of what we may know about the effects of circadian lighting on human health and wellbeing, we may never be able to codify this knowledge in building design practices.”

Other detractors are less pessimistic. But many are still concerned both with the complexity of the science and whether the industry is overreaching in its claims, especially since investigators are still wrestling with how best to quantify them.

In her 2018 article *Age of Enlightenment: The Promise of Circadian Lighting*, published by Undark, Lynne Peeples quotes lighting consultant James Benya as saying, “...without guiding science, and with the lack of protocols and standards, right now it is the Wild West.” And in their report on the Carrollton classroom study, the DOE said that empirically measuring the effects of the circadian lights was beyond the scope of the project, noting the challenge of “documenting and assigning economic value to non-energy benefits.”

Some have even drawn a parallel between designers and architects specifying human-centric lighting and physicians prescribing medicine or supplements, suggesting that the lighting industry must adopt a stance like the physician’s oath: First, do no harm.
Where To Go From Here

Even critics of acting now on human-centric lighting acknowledge the benefits available currently and its compelling promise for the future.

In her article, Peeples also quoted Benya as saying, "We know it is going to have a significant benefit for many people," and the IES appended Ashdown’s article with the recommendation that "we should simply educate designers on the principles of circadian lighting and trust their judgment."

It’s now 2020, and while adoption of human-centric lighting has been creeping forward over the last 10 years, it is accelerating fast today. Some manufacturers are already promoting “spec lighting that’s also circadian friendly.”

Cree Lighting’s Cadiant™ Dynamic Lighting Experience was developed for a specialized function – to bring a realistic feeling of the outdoors into spaces where it was not otherwise possible to put windows or a real skylight. The product, along with others from Cree Lighting, features the dimming, color tuning and spectral content needed to positively impact human performance and wellbeing.
Education is among the industries expected to take an early lead in adopting tunable, flexible health-centric lighting, along with healthcare and assisted living. Many lighting manufacturers already offer health-centric solutions specific to these industries, both for new construction and to retrofit existing facilities.

Most people are familiar with the consumer categories for buying behavior when embracing a new technology or industry shift: early adopters, early majority, late majority and laggards. There are risks and benefits associated with each, and making the right choice for human-centric lighting will largely depend on your specific goals, priorities and values.

The best advice is to ensure the lighting choices you make today are “future-proof” — meaning a flexible, intelligent lighting solution that’s sufficiently configurable and programmable to utilize new research findings as they are validated.

Because whether you’re ready now – or not quite yet – lighting optimized for human health, performance and well-being is likely to be the next major game-changer in the lighting industry.