BioCentric Lighting™ in Education

The physical learning environment can influence student academic success and behavior. Lighting has traditionally focused on the visual requirements for the activity to be performed, to provide light for reading, work together and socialize. Most people are not aware of the importance of the influence that the lighting environment has for wellbeing, learning and sleep. New research has pointed out the importance of light as an enabler in the school environment and important synchronizer of circadian rhythm and sleep.
Fluorescent lighting systems are the most prevalent sources of illumination in schools.
By their physical nature, they don't provide the wavelengths necessary to entrain the daily rhythm that is needed to synchronize the sleep/wake rhythm with the solar day. As sleeping problems are increasing among children, providing a learning environment that enhance learning but also promote night sleep is becoming increasingly important. Without enough sleep, learning is compromised.

Light can boost learning

There is emerging research showing that light can have a profound effect on children's learning capabilities. Light detection takes place in the retina. In addition to classical rod and cone photoreceptors, a sub-population of retinal ganglion cells constitutes a new third type

of photoreceptors. They are activated primarily by blue light i.e. light with shorter wavelength with a peak around 480 nm. These ganglion cells project and, when activated, induce activity in areas in the brain important for alertness and learning such as the hippocampal area in the midbrain and the prefrontal cortex. MRI-experiments illustrating increased activity in these specific brain regions have shown that light can modulate brain responses to cognitive tasks already after a few minutes exposure. When exposed to bright light, and specifically blue light, it induces a feeling of increased alertness among test subjects. Similar to these experiments, studies have shown that modulation of brain activity elicited by cognitive processes are wavelength dependent, with a pre-eminence of blue light in eliciting these effects.

Blue light can improve learning

In a study among developing adolescents, blue-enriched (compared to red-enriched) light was associated with improved performance on a mathematical task. In another study, high school students working under a variable lighting environment including very bright cold light (1 060 lx, 5800 K) made fewer errors and increased reading speed and comprehension using this bright cold light. Both students and teachers rated the lighting environment positively and found it useful during lessons. In a study comparing younger children, higher correlated color temperature (CCT) of 5 000 K lead to greater improvement in a task switching performance compared to 3 500 K.

In a on site setting, LED lighting was compared to fluorescent lighting with the same CCT levels (4 000 K) among a group of preschool children, 3-4 years of age. In LED lighting the children displayed a more engaged behavior compared to fluorescent lighting.

Light may also impact long-term performance. Experiments have shown that memory consolidation in certain light conditions can affect learning capabilities. In one study, individuals who were exposed to 30 min blue light during memory consolidation showed a better recall compared to individuals exposed to amber light. In a long-term study investigating the oral fluency reading scores among 3-graders over the course of an academic year, pupils training in a white bright light (1 000 lx 6 500 K) performed much better than those training in regular classroom setting (500 lx, 3 500 K) (Mott 2014).

These findings, in combination with earlier lighting research, suggest that artificial

lighting plays a key role in helping to create an effective learning environment. Variable lighting helps teachers achieve learning outcomes with lighting that supports specific tasks, such as calculus, quiet reading or group work. Bluish bright light could be used for attention demanding tasks. During rest, a warm light composition could be used for a calmer atmosphere.

Light has a positive impact on mood

Lighting within a room influences our mood state. Adequate lighting is associated with a feeling of happiness while dark lighting induces feelings of depression. It has been shown in experiments with MRI chambers that light affect areas in the brain important for our feelings. In these and other experiments it has been shown that light, and especially blue light, seems to have a direct mood enhancing effect. Grown ups and young adults

Light makes us happy

rate their mood higher after bright light exposure and again blue light gives the highest effect. Studies show that adolescents that do not receive enough light are more susceptible for depressions. A growing number of students on college campuses seek help for depressive symptoms such as profound sadness, low motivation and suicidal behaviors. In a study investigating 79 college students suffering from depression, light treatment showed improvement in overall depression scores as well as improved sleep with an increase in average night sleep from 5 to 7 hours. In another study it was found that the students who were exposed to the least daylight were the ones feeling the worst. They were more depressed, had worse sleep and were more stressed. When wearing glasses that provided “daylight”, their mood changed and they were feeling better. They also became more alert in the morning and had a better sleep.

Light can improve alertness and mood

In addition to improving mood, improved light exposure has also been shown to have other positive effects. Better light in the school reduces the children's level of stress according to a number of Swedish professors in the newspaper “Ny Teknik”.

Many students are sleep deprived

There are many studies showing an increasing amount of children having sleeping problems and about 25% of children are reported having some form of sleep disorder during childhood. Adolescents often have a delay in bedtime.

Pereira et al found that delay in bedtime was greater among adolescents living in an urban area compared to a rural area without electricity. Probably our modern lifestyle with indoor living, artificial lighting not stimulating the circadian rhythm and light emitting screens at night make it difficult for entrainment to a solar day with "social jetlag" being a common problem among adolescents. Children today sleep too little and much less than before and the amount of sleep among children has diminished by 1 hour only the last 10 years.

Today children spend about 85% of their time indoors. Schooling but also recreational activities that often take place indoors, give little opportunity to stay outdoors in daylight. Given the high proportion of children who have problems with their sleep, it is not surprising that melatonin prescription as a mean to aid children sleep is increasing. Also in the long term lack of sleep is a problem, as short sleep in young age is correlated with higher BMI as an adult.

Sleep deprivation has detrimental effect on memory and learning

Sleep is important for well-being, social competence and academic performance. Sleep enhances neural plasticity and increments learning and memory and irregular sleep has been related to lower academic performance.

Adequate sleep is necessary to be able to focus attention on what is to be learned. But sleep is also important for the consolidation of memories, which is essential for learning new information (Harvard). During sleep neural connections that form our memories are strengthened (Harvard). Sleep deprivation leaves the brain exhausted and makes it more difficult to concentrate and learn new things. Without adequate sleep, neurons can no longer coordinate information properly and we loose our ability to access previously learned information.

Appropriate light can improve sleep

These facts are not merely a theoretical explanation, but are also evident in academic performance. Several studies highlights the fact that many students, from school to university, are chronically sleep deprived or suffer from poor sleep quality and that this is closely related to learning and their performance. Furthermore, studies show that for individuals in which sleep was optimized, an improvement in neurocognitive and academic performance was made.

Light to restore a disturbed sleep

In the evening the sleep hormone melatonin makes us tired and it peaks in the middle of the night. When we wake up, daylight has a suppressing effect on the release of melatonin and we feel alert. The sleep-wake rhythm needs to be aligned daily not to fall out of sync with the solar day. This synchronization is made by light hitting the retina activating this new third type of photoreceptor (see above) that is

activated primarily by blue light. Without this activation, the release of melatonin in the evening gets delayed and sleep gets pushed to a later hour. A viscous circle with later bedtime and less sleep becomes the result as is often seen among adolescents. Furthermore, light at night can further delay the onset of melatonin and studies have shown that children are more susceptible to light exposure compared to adults and adolescents.

Sleep problems and delayed sleep rhythms are common among children. Light exposure during daytime can restore a disturbed rhythm by activating the time keeping centra located in the suprachiasmatic nuclei, the Master clock, in the brain. This synchronization is primarily made via the ganglion cells in the retina that are most sensitive to blue light. These ganglion cells directly influence the master clock so that the diurnal rhythm is shifted back in phase with the solar day. With BioCentric Lighting™ (BCL™), interior light can be controlled so that it dynamically changes during the day in the way daylight does and provides synchronization for the Master clock.

In a thesis from Lund University Faculty of Engineering, the effect of BCL™ and standard lighting on sleep among school teen-agers was investigated. Sleep was improved in the group with BCL™ with fewer nightly awakenings compared to the group with standard lighting.

The human circadian system is also influenced by prior lighting and light exposure daytime protects against aberrant light in the evening. In studies by Kozaki et al, 900 lx of white light (4523 K) or 79 lx of bluish white light (9584K) in the morning were enough to protect against night light exposure (300 lx) that would otherwise have induced a drop in night-time melatonin.

Light can alleviate symptoms in ADHD

ADHD (Attention Deficit Hyperactivity Disorder) is a neurodevelopmental condition with increasing prevalence affecting around 7-8% of children. It often continues into adulthood.

Roughly two thirds of children with diagnosed ADHD take medication for this condition and about half of them are also prescribed melatonin. Prescription of drugs for sleep-related disorders such as insomnia and ADHD has increased in Sweden. Research has shown that a majority of individuals with ADHD have a delayed sleep onset, a later increase in the onset of melatonin at night and an association with evening chronotype “night owls”. There are reports indicating that ADHD could be related to changes in the genes that influence the internal diurnal rhythm, the CLOCK genes.

Less impulsiveness and increased attention with light

Light therapy has shown promising effects in alleviating symptoms among ADHD patients. In one study they found several improvements; improved symptoms of impulsiveness, inattention, difficulty sustaining effort and fatigue, improved mood symptoms and an advance in circadian preference i.e. earlier bed time. In another study they found that light therapy led to earlier release of melatonin and an earlier sleep phase. In a third study involving 11-17 year olds, blue-enriched light during a cognitive task resulted in reduced variability in reaction times reflecting a more stable attention under blue-enriched light. The authors points to the possibility in using this type of light for individuals with ADHD.

Children with ADHD are sensitive to the light environment

Many children with ADHD are excessively sensitive to the quality of lighting. In one study comparing LED and fluorescent lighting, children with developmental disabilities were the ones having the most change in engagement behaviors favoring the LED lighting environment. The authors speculate regarding this being partly contributable to the flicker effect in the fluorescent lamps since even though not visible to the average human eye, special populations, like children with ADHD, can still be influenced by the oscillation.

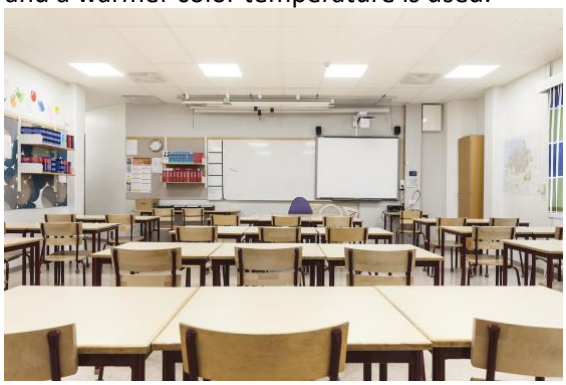
Light exposure influence the growth of the eye

Myopia is characterized by a growth of the eye where the eye is becoming too long in relation to the optics of the eye, placing the image in front of the retina. An epidemic of myopia is sweeping through Asia where in some countries as many as 80% of young adults are myopic. Too much time spent studying indoors and not enough time spent outside in daylight are thought to be contributing factors for this. In a recent report, the results showed that spending time outdoors in daylight could be preventive for the development of myopia (Rose 2016). In another recently published report, it was shown that receiving less than 40 min of bright daily light (> 1,000 lx) could predispose to faster growth of the eye. The researchers speculated on whether a minimum amount of light was necessary to reduce growth. Time and intensity of light exposure seemed both to be crucial factors in influencing the development of myopia .

Lighting as a tool in the educational environment

As shown above, light is important to entrain the diurnal rhythm but can also be used to optimize learning environments. In a school setting in Malmö in Sweden, the teachers are using BCL™ in their education to support activities but also to create structure for the day. In the standard setting the light changes dynamically in a day-like manner. “Activity” setting is chosen when the children are working and need to concentrate. The light is more intense and with a higher CCT.

"Smartboard" is chosen when the teacher is presenting on a smart board; middle intensity and a somewhat warmer color temperature. "Relax" is chosen for socializing or storytelling; a lower intensity and a warmer color temperature is used.



Modern education uses light to improve learning

Lighting plays a key role in helping to create an efficient learning environment to ensure students reach their full potential. Children are particularly sensitive to different lighting environments and the light that is suitable for an adult may not be suitable for a child. This research is still evolving. The BioCentric Lighting™ system is easily customized according to the unique needs of the individual workplace. The light environment provides students and staff with the light that they need each day, regardless of season. Emerging research provide new understandings of the beneficial effects of different lighting environments in an educational setting. The BCL™ system is easily adaptable to meet these new insights.

Summary

- Light can focus attention and boost memory
- Light has a positive impact on mood
- Many children and adolescents are sleep deprived
- Sleep deprivation impairs memory
- With adequate lighting, a normal sleep-wake rhythm can be restored
- Treating sleep disorder in ADHD by improved lighting may alleviate symptoms of ADHD
- Light can be a tool in the educational environment

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