Case Studies on Light's Effect on Student Performance and Behavior

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MIDWEST LIGHTING INSTITUTE

Midwest Lighting Institute

Mission: MLI will foster innovative applications of new energy-saving lighting technologies through MLI-funded research that speeds adoption and understanding of those technologies for the improvement of human health, safety, and productivity.

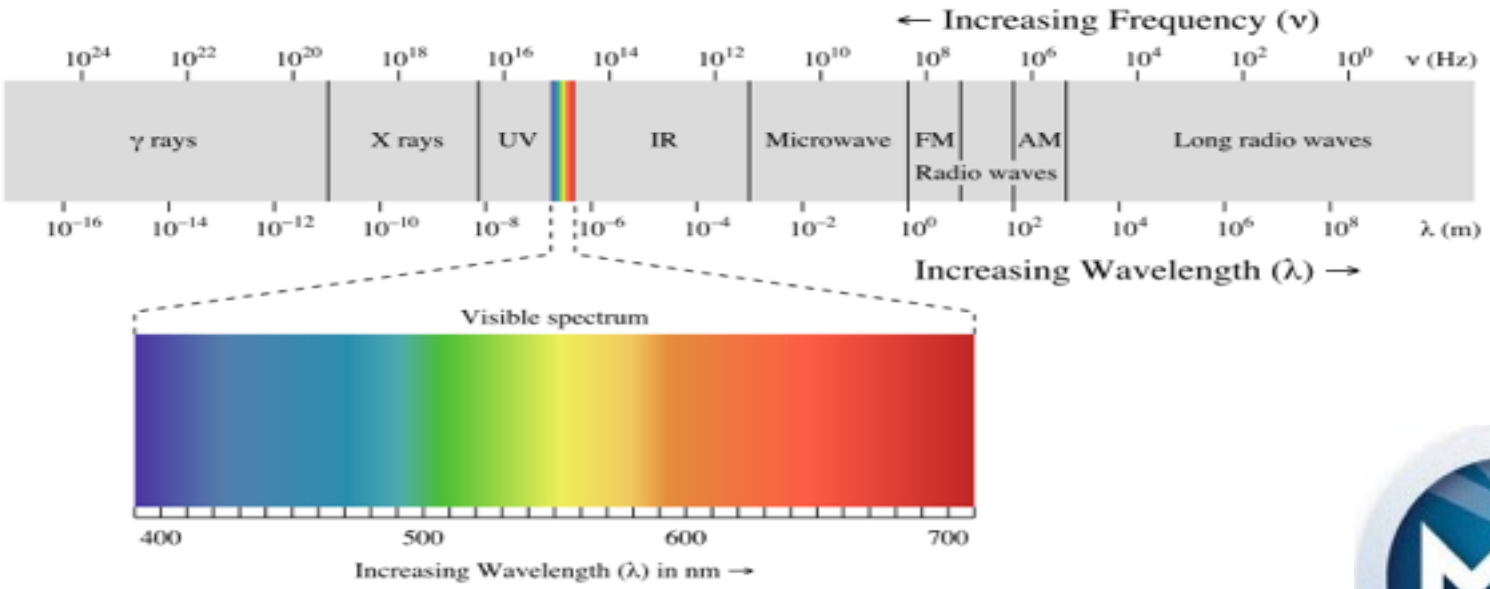
Where Do We Start?

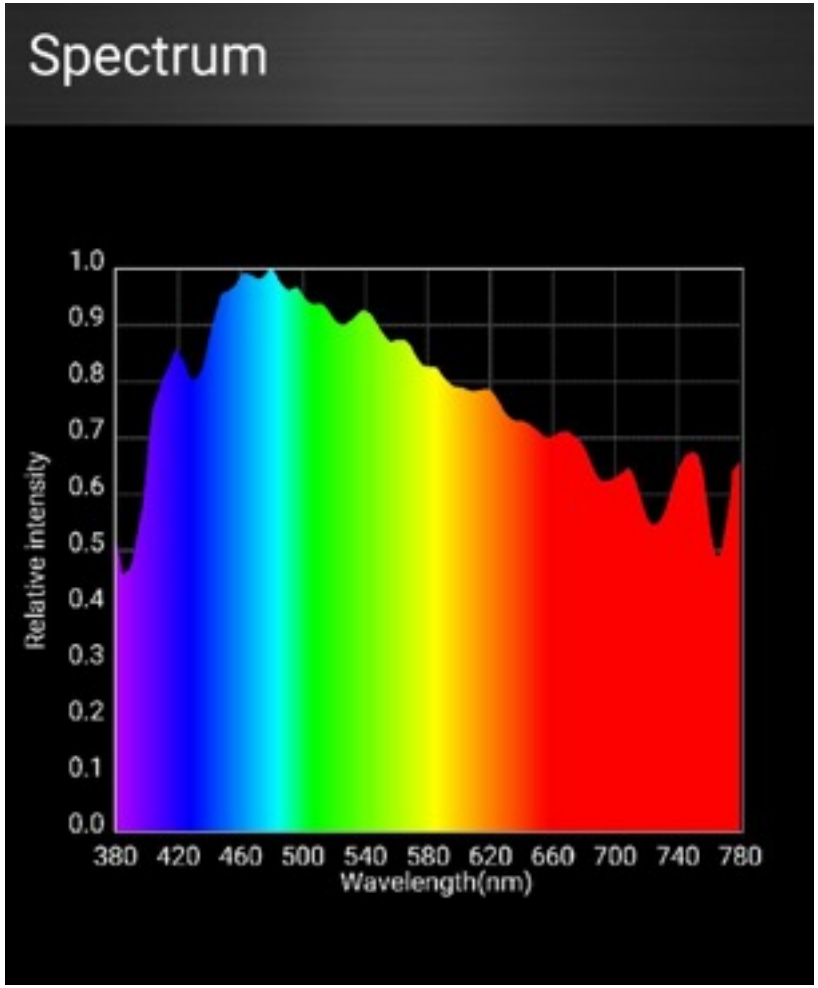
PHOTORECPTORS!

- 2 visual photoreceptors - Rods & Cones
  - Cones- Photopic –day vision
  - Rods - Scotopic –night vision
- 1 non-visual photoreceptor - Ganglion cells
  - ipRGC
  - Discovered about 15 years ago
  - Most primitive form of vision in mammals
  - Tells us day & night & time of year
  - Resets the body's circadian clock

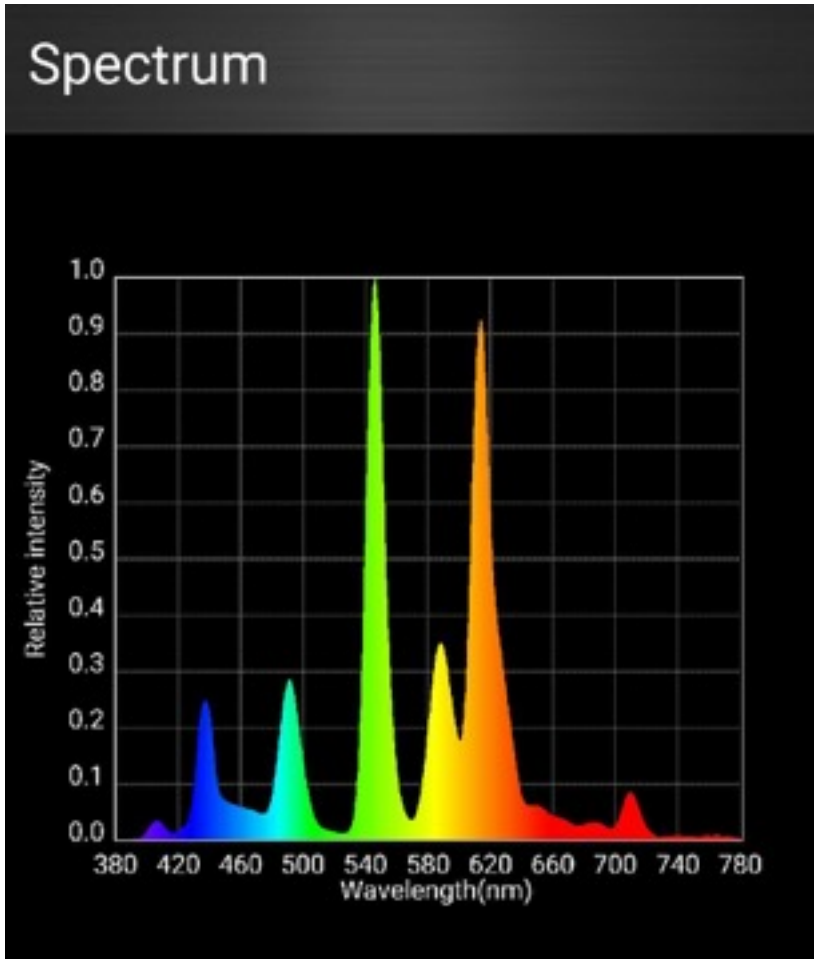
Importance of Ganglion Cells

- Trigger the production of cortisol & melatonin based on color of light hitting pupil
- 460-480nm has greatest effect on melatonin suppression

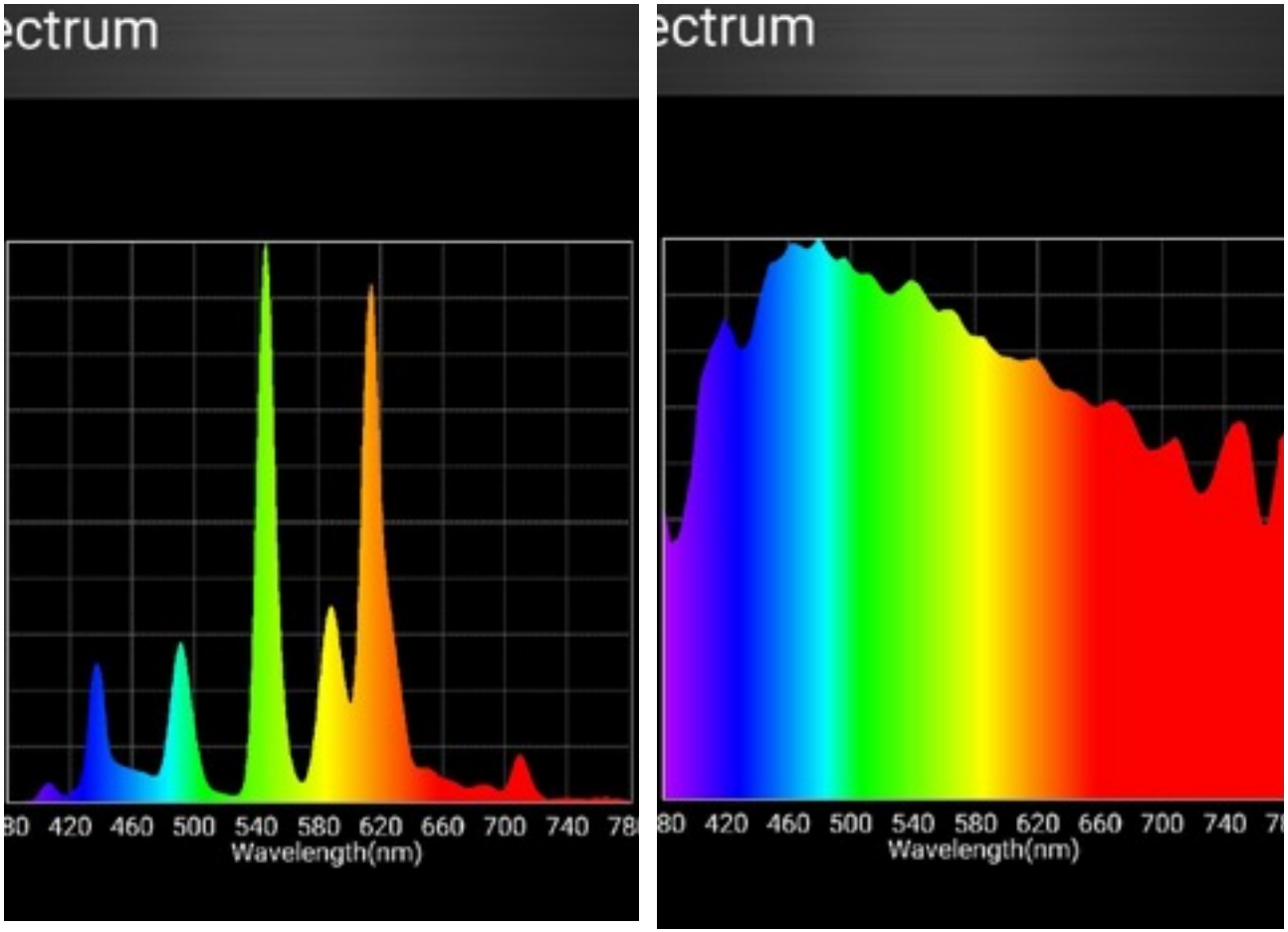




Outdoors in the Shade



4000k fluorescent lighting



Missing Spectrum

Nonvisual Photoreception

Neuroendocrine & neurobehavioral responses

- Direct immediate effects of light
  - Improves subjective alertness
  - Improve neurobehavioral performance
  - Induces melatonin suppression
  - Induces cortisol stimulation (at some times of day)
  - Increases heart rate and body temperature
  - Drives pupillary constriction response

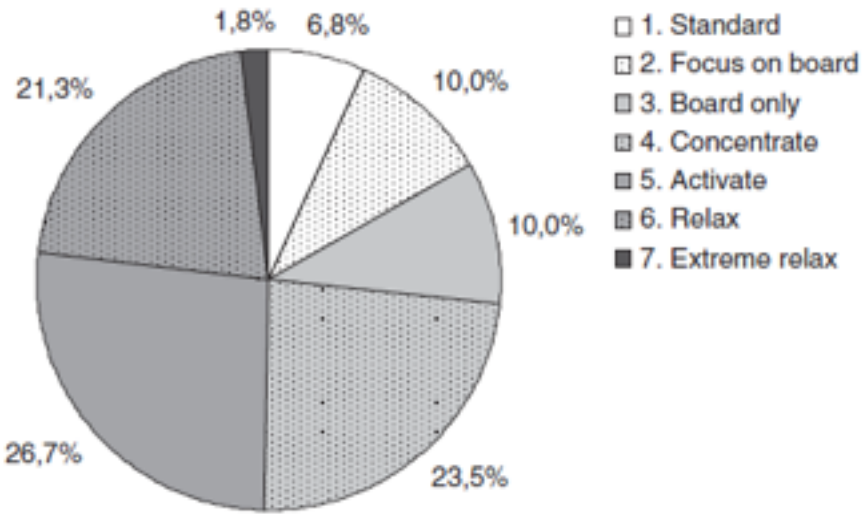
Published Studies
Prepared by Dr. Steven Lockley

Harvard Medical School
Brigham & Women's Hospital -Boston

Physiological Response

- Blue enriched light, short wave length light has been shown to improve student performance
- Illuminating of Dynamic Lighting on Student Learning
  - *Mott, Robinson, Walden, Burnette, Rutherford*
- Lighting Affects Students' Concentration Positively: Findings from three Dutch studies
  - *Sleegers, Moolenaar, Galetzka, Pruyn, Sarrough et al.*
- Influence of blue-enriched classroom lighting on students' cognitive performance
  - *Keis, Helbig, Streb, Hille*
- Many more studies available!

Applicability and efficacy of variable light in schools



Dynamic lighting system
Philips T5 fluorescent lamps
'Concentrate': 5800K, 1060 lux
'Activate': 11000K, 675 lux
'Relax': 3500K, 325 lux
'Extreme Relax': 3500K, 275 lux
'Board only': 4000K, 1000 lux at board
'Focus on board': plus 3800K, 300 lux

Standard lighting
4000K, 300 lux

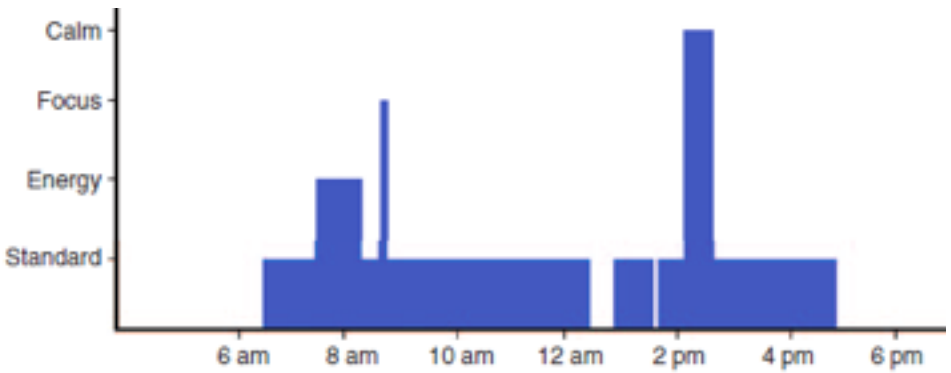
Two schools studied before (Oct) and after (Jan-Feb) installation with two classrooms (n=116)
Classroom 1 – Dynamic lighting, teacher-led
Classroom 2 – Standard

A greater improvement was observed in concentration and reading between the Concentrate and Standard settings, but there was no difference in the pupils' attitude to school.

Similarly, Mott et al. (Sage Open, 2012) studied 84 US third-graders (aged 7-8 yrs) under the Normal (500 lux, 3500K) *vs* **Focus (1000 lux, 6500K)** conditions and the higher CCT lighting was reported to have led to a quicker improvement in oral reading fluency performance when assessed over a full calendar year. The concentration test did not show any differences.

Barkmann et al., Physiol Behav, 2012

Lighting affects students' concentration positively: Findings from three Dutch studies



Dynamic lighting system

Philips T5 fluorescent lamps

'Energy': 12000K, 650 lux

'Focus': 6500K, 1000 lux

'Calm': 2900K, 300 lux

Standard lighting

3000 - 4000K, 300 lux

Standard concentration task (9-10am) before and then 4-5 weeks after installation

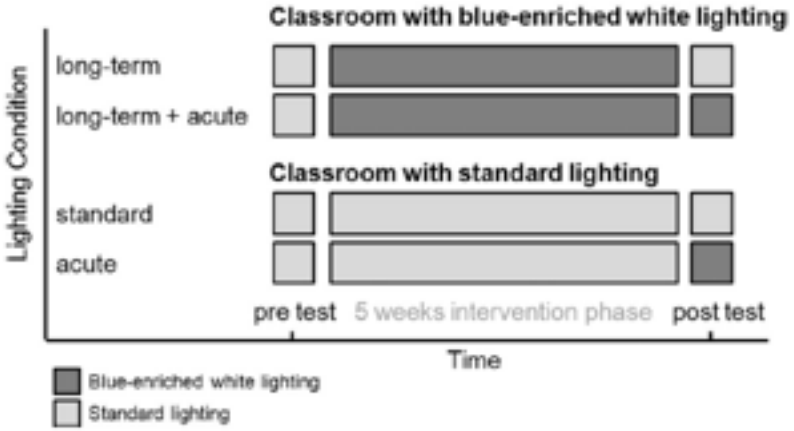
School 1 – Dynamic lighting system (n=98)

School 2 – Focus setting only (n=44)

The school-based studies showed that younger pupils (Grade 4) working under the focus light setting had significantly better concentration and fewer errors as compared to the control groups. Older children (Grade 6) did not differ between conditions.

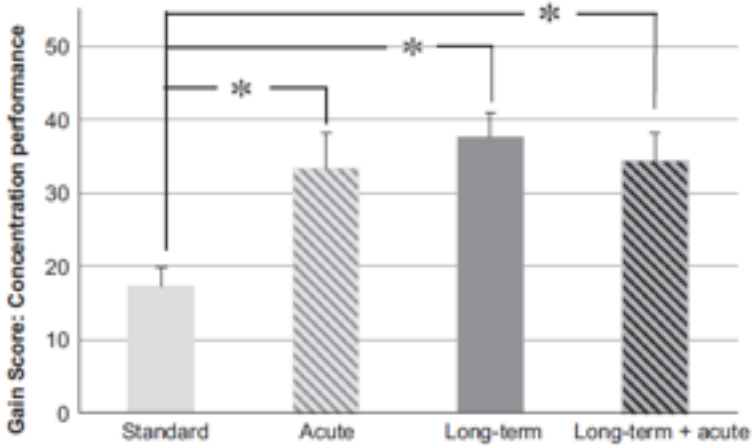
Sleegers et al., Light Res Technol, 2012

Influence of blue-enriched white lighting (LED) on students‘ cognitive performance



LED lighting system
Osram 4000K and 14000K lamps to average 5500K, ~300 lux (vertical)

Standard lighting
T8/T5 fluorescent 3000K and 4000K to average ~300 lux



Significant improvement in performance with blue-enriched white light

Keis et al., Trends Neurosci Educ, 2014

General Agreement

- High contrast between day and night help daytime alertness and circadian stability
- If daylight is not available, then built space lighting should have high intensity and blue enriched light (5000K or above)
- Night lighting should be dimmer and more orange/red
- Special consideration for classrooms with challenged students

Case Studies – Our Experience

Des Moines, IA

- Tunable or Dynamic Lighting installed in special needs school
  - Mike Lambert designer
  - 50% energy savings to pay for upgrade
  - Calming effect on escalating behavior
  - Stopped self-inflicted negative behavior
  - Increased concentration
  - Non-physical handling of problem situations
  - Technology control was not perfect

De Soto, WI

- Tunable or Dynamic Lighting installed in special needs classroom
  - Helped to control seizures in a student
  - Teachers noted increased interest in students and used as a key to help guide students to expected behavior
  - Teachers reported really using 2 of the 4 settings: high intensity blue and low intensity yellow
  - Used federal funds granted per student to fund the facility upgrade

Stoughton, WI

- Tunable or Dynamic Lighting installed in 5 classrooms
  - 3 elementary school rooms retrofitted
  - 2 high school rooms retrofitted; science rooms had static blue installed over the work stations
  - All classrooms without windows
  - Each controller had 4 pre-set options, plus ability to dim
  - Chromebooks in use in the high school

Stoughton, WI

- Project paid for by Stoughton Utilities, American Public Power Association DEED Grant, MLI, and WPPI Energy
- 70% energy savings
- Cost around $5,000 per classroom for dynamic with multiple banks of lights and 3 controllers

Stoughton, WI

- Welcome Cory Neeley, Energy Services Representative with WPPI Energy serving Stoughton Utilities
- Calvin Merath with Stoughton School District

Summary

- Rich blue light is needed in the classroom
- Energy savings is more than 50%
- Design light for the occupant and energy savings fall into place
- Learn from the experiences of others
- Join us for a special webinar on March 28 at 8:30 am for more information

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Thank you

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