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Why Tunable? A Look at Schools Installing Tunable Lighting

November 2024

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U.S. DEPARTMENT of ENERGY

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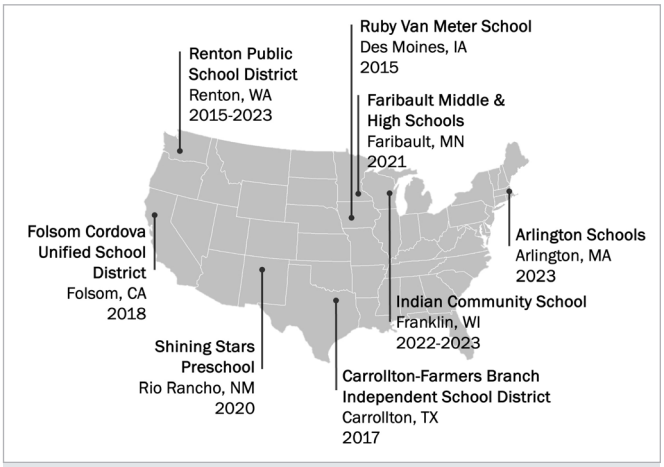
Why Tunable? A Look at Schools Using Tunable Lighting

LED technology enables dynamic lighting solutions that can adapt to the occupants, tasks, and daylight in a space. Tunable lighting systems can alter the intensity and/or spectral characteristics (color) of the source. As more schools across the U.S. transition from fluorescent to LED technology, many are likely to consider tunable lighting. This case study aims to help decision-makers by looking at past and current tunable lighting projects.

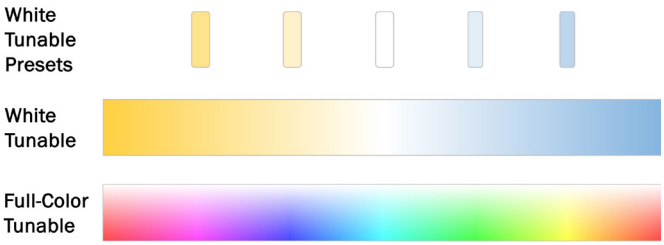
Between 2016 and 2019, Pacific Northwest National Laboratory (PNNL) documented two early pilot installations of tunable lighting in schools [1, 2], supported by the U.S. Department of Energy (DOE) Solid-State Lighting (SSL) program. These pilot installations gave the schools an opportunity to become more familiar with the technology, save energy, and support teachers and students. Interest in tunable lighting in schools continues to grow, particularly to support students with disabilities, and more schools have started to explore tunable lighting options. This case study looks at tunable lighting systems installed in classrooms at eight school districts across the U.S. since 2015, the earliest known installation, to explore the following questions:

- Why did schools choose tunable lighting?
- What features were selected?
- How was tunable lighting implemented?
- What was the teacher feedback?

The installations were a mix of new construction and fixture replacement, ranging from a few classrooms in a single school, to all classrooms within a school, to multiple classrooms and schools across a district. The earlier installations tended to start as pilot projects to gain experience with tunable lighting and assess potential benefits before expanding to additional classrooms.



This case study examines tunable lighting installations at eight school districts across the United States.



White Tunable – varies color of light from warm to neutral to cool.

Full-Color Tunable – varies color of light in a range of white to saturated colors.

Implementation

Each installation of tunable lighting was unique, implementing a variety of tuning methods, color ranges, and control options. Most classrooms had a white-tunable lighting system with correlated color temperature (CCT) options typically ranging from 2700 to 6500 K, although one school had a CCT range of 1800 to 8000 K. Only one installation was full-color tunable, providing a wider range of options including saturated colors. The table on p. 4 summarizes the implementation of tunable lighting installations across the different districts.

The figure on p. 3 shows how control interfaces varied among installations, from physical switches and buttons to touchscreens and phone apps, and also illustrates how the interfaces offered varying levels of manual control over the color tuning options. In one project, a sensor placed on the roof of the building automatically tuned the color of the lighting system based on the daylight conditions, aiming to connect the indoor experience with the outdoor environment. For this installation, control interfaces offered on, off, and intensity of the electric lighting system, but no further customization of color. In other schools, color control methods included preset control options, customizable control, or a combination of the two. Interfaces with preset control options limited color selection to predetermined settings, with the ability to manually change intensity from 0% to 100%. More customizable control could include additional manual adjustment of color via the interface, enabling users to select from the entire range of color options, or customization of the intensity and color of more than one lighting zone (e.g., overhead vs. whiteboard).

PNNL Field Evaluations

Pacific Northwest National Laboratory conducts field evaluations of advanced solid-state lighting systems to collect empirical data and document building owner and end-user experience with lighting systems. The evaluations produce independent, third-party data and recommendations for use in decision-making by lighting manufacturers, designers, facility managers, and other professionals. Real-world installations often reveal product limitations and application issues that are not apparent from laboratory testing. The evaluations include feedback from the people who live, work, and play under the lighting systems in a variety of space types.

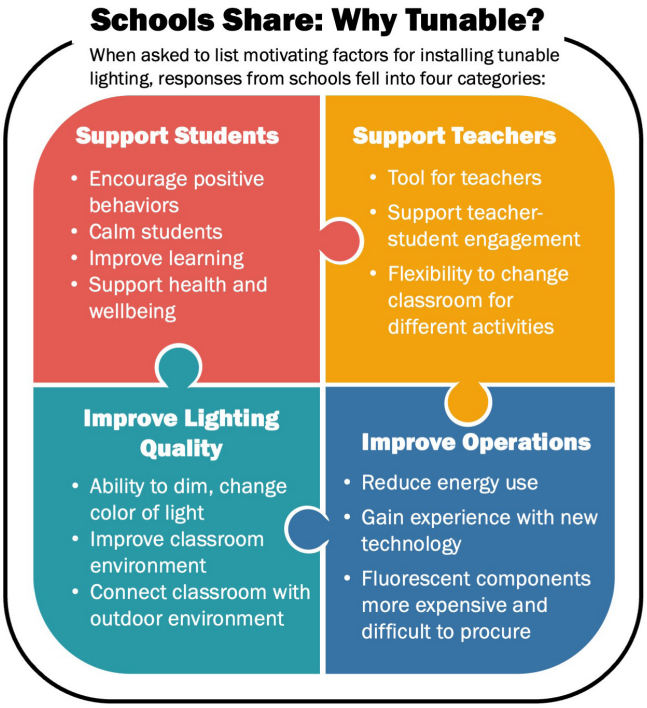
Motivation

Schools were asked: Why tunable lighting? While the responses included motivating factors that could benefit the entire student population in PK-12 schools, many specifically mentioned supporting students and staff in special education classrooms. Teachers in these classrooms may be more open to using new tools for cueing desired behaviors.

Feedback

Teachers responded positively to the tunable lighting systems in their classrooms, indicating the lighting improved the working and learning environment for themselves and their students. Teachers from multiple schools repeatedly mentioned changing the lighting setting as a cue to students that it was time to transition between activities, to quiet down, or to draw their attention back to the teacher; this cueing method was more effective than previous methods like ringing a bell or speaking loudly. The preset control options were particularly helpful, as teachers could quickly adjust the lighting. Teachers also indicated that the tunable lighting systems increased student engagement, with students requesting certain settings or offering to help adjust the lighting between activities. While staff observed a net increase in positive behaviors, one school mentioned that distraction was one of the biggest challenges of the lighting, as students needed to be reminded not to change the lighting setting or turn the lighting off.

More objective feedback was also collected for two schools [2, 3] to understand how teachers were using the tunable lighting systems in their classrooms day to day. Lighting control data, collected via connected laptops



in one school and manually in another, highlighted the different lighting preferences among teachers as they used the lighting to suit the needs of their classroom. Some teachers made very few adjustments once they found a setting they preferred; others adjusted the lighting many times throughout the school day. It was most common for teachers to adjust lighting intensity; however, color adjustments were also made daily. Presets were commonly used (e.g., in multiple schools, teachers regularly used a visually warm and dim setting for 5 to 10 minutes following recess, then switched to a higher intensity and visually cooler setting). When asked what they would like to change about the lighting, schools mentioned control methods repeatedly, with one school recommending simpler control options. Another school suggested adding a remote so teachers could control the lights as they moved about the classroom, although they did not support the use of a mobile touchpad or smartphone as the controlling device.

Additional Considerations

The cost of the tunable lighting systems was not collected. Lighting system product and installation costs vary regionally, and while tunable system costs have decreased considerably since 2015, they still cost more than systems with no ability to alter intensity and color. Generally, systems with simpler features will have a lower initial cost, and these systems typically have lower installation and commissioning costs. One teacher noted that simply having the ability to change the intensity of the light was beneficial. Installing lighting with intensity control provides an opportunity to save energy, and often does not change the lighting fixture price because LEDs are inherently dimmable, whereas fluorescent fixtures require a special and more costly ballast for dimming capabilities. LED products often also come with warranties for fixtures and fixture components such as drivers.

Tunable lighting control methods for tuning color. *Photos courtesy of (l. to r.) Crestron Electronics, Inc. (All rights reserved); ABL; Finelite; The Retrofit Companies, Inc.*

Comparison of tunable lighting installations across eight school districts.

School or District	Size of Installation	Replace Fixture or New Construction	Tuning Method	Color Range
Arlington Schools	All 28 special education and preschool classrooms	New Construction	WT	2400 – 4000 K
Carrollton-Farmers Branch Independent School District	3 classrooms at 3 different schools (4th, 5th, and 8th grade)	Replace Fixture	WT Presets	3000 K, 3500 K, 4200 K, 5000 K
Faribault Middle School and High School	All special education classrooms	Replace Fixture	FT	
Folsom Cordova Unified School District	3 classrooms in the same elementary school, 2 serving students with autism spectrum disorder	Replace Fixture	WT	2700 – 6500 K
Indian Community School	All classrooms and common areas	Replace Fixture	WT	2700 – 6500 K
Renton Public School District	Over 200 classrooms across district, 24 of which are special education classrooms	Both	WT and WT Preset	2700 K – 6500 K or 2700 K, 4000 K, 6500 K
Ruby Van Meter School	All special education classrooms	Replace Fixture	WT	2700 – 6500 K
Shining Stars Preschool	All 30 classrooms	New Construction	WT	1800 – 8000 K

WT = white tunable; FT = full-color tunable

Acknowledgments

This project would not have been possible without the collaboration and cooperation of the staff members who were willing to provide feedback and details on their schools' tunable lighting systems. This work was supported by the DOE Building Technologies Office (BTO) within the Office of Energy Efficiency and Renewable Energy (EERE). ■

Resources

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