

# The Inclusive Classroom: Effects of Classroom Lighting on Students with ASD

## RESEARCH TEAM:

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## EXECUTIVE SUMMARY

### ABSTRACT

Interior lighting influences human development, function, and behavior. Light-Emitting Diodes (LEDs) are becoming the most common lighting fixture due to their long lifespan, energy efficiency, and low maintenance; however, the influence of LEDs on children's behavior, learning, and academic success remains unknown. Children with Autism Spectrum Disorder (ASD) process and respond to stimuli faster than adults and react differently to visual light. Limited lighting studies have been performed in actual classroom environments or focused on children. The long-term goal is to identify the appropriate correlated color temperature (CCT) of LED lighting to install in classrooms since CCT levels are not specified in architectural codes. The CCT of lighting is known to influence human behavior and refers to the temperature of the light, from warm to cool. As more schools switch to LED lighting, there is a critical need to determine the influence of LEDs on ASD student behavior, learning, and academic success to create an inclusive general education classroom.

### PURPOSE OF STUDY

The study began with the identification of a critical issue: how classroom lighting affects students with Autism Spectrum Disorder (ASD). The idea was inspired by existing gaps in architectural standards and the specific needs of students with sensory sensitivities. The long-term goal of this research is to develop classroom lighting guidelines that support Universal Design for Learning, which is defined as spaces built for meaningful inclusion of students with disabilities.<sup>1</sup> The objective of this study is to determine

the appropriate correlated color temperature (CCT) of Light-Emitting Diodes (LEDs) to promote positive interactions between ASD students and teachers, peers, and tasks, as CCT is not specified in codes or standards for classroom spaces. As more schools switch to LED lighting, coupled with the need to create an inclusive general education classroom, there is a critical need to determine how LEDs influence ASD student behavior to design Universal Design for Learning public school classrooms.

## RESEARCH SUMMARY

### BACKGROUND

Interior lighting has a significant impact on the built environment, reducing visual fatigue and influencing human development, functionality, and behavior.<sup>2</sup> LEDs, favored for their long lifespan, energy efficiency, and low maintenance, are now the predominant lighting choice in U.S. facilities.<sup>3</sup> White tunable LEDs, which allow adjustments in correlated color temperature (CCT) measured in kelvins, offer versatility; however, classroom lighting standards currently lack specific guidelines for CCT.<sup>4</sup> The CCT of lighting describes the color of light emitted by a source, ranging from warm red tones at lower Kelvin values to cool blue tones at higher Kelvin values.

Approximately 1 in 59 children in the U.S. are diagnosed with Autism Spectrum Disorder (ASD), many attending public schools.<sup>5</sup> These students often experience heightened sensory sensitivities, including reactions to lighting, which can affect their learning and behavior.<sup>6</sup> Sensory challenges associated with ASD can hinder academic performance due to increased stress and competition for cognitive resources.<sup>7</sup> Optimizing classroom CCT levels could enhance learning environments for all students, especially those with ASD.

### METHODOLOGY

The research team comprised faculty and design professionals to create a collaborative approach, ensuring diverse perspectives in research design and execution. The team had expertise in educational facility design, lighting design, and ASD-specific studies. Together, the research team created a study utilizing a convenience sample to examine how varying CCT levels of white tunable LED lighting influence the interactions of students with ASD, focusing on:

1. Identifying CCT levels that enhance interactions with teachers, peers, and tasks.
2. Exploring gender-based differences in these interactions under different CCT levels.

After university IRB approval, a within-subjects design was used in a Pacific Northwest public school classroom without any exterior windows. White tunable LED fixtures were installed, alternating between low CCT (3000K) and high CCT (5000K) settings in an ABAB pattern. Twelve ASD students (8 female, 4 male) and one female teacher participated.

**Lamp A – Low CCT**



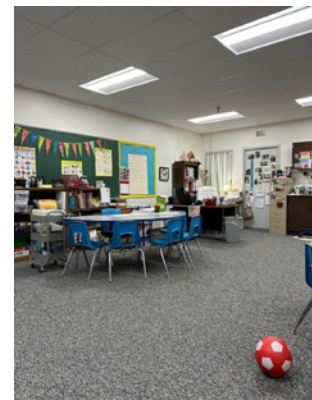
**Lamp B – High CCT**

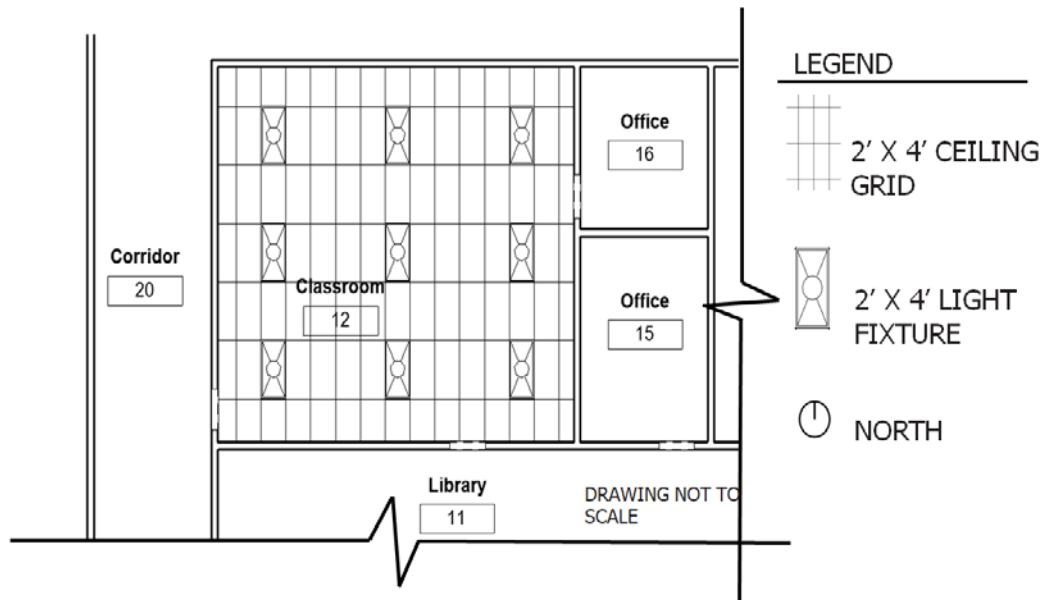


**Lamp A – Low CCT**



**Lamp B – High CCT**





**Classroom Ceiling Plan**

Student behaviors were collected using the Individualized Classroom Assessment Scoring System (inCLASS), a validated tool widely used in educational research involving ASD populations.<sup>8</sup> Other environmental variables, such as temperature and noise, in addition to day of week and time of day, were collected. Data were input into SPSS and analyzed with ANOVA to evaluate differences in interactions based on lighting conditions, while accounting for other variables.

Observations and analyses focused on the students' interactions with the teacher, their peers, and the task to evaluate behavioral outcomes. The study concluded with a comprehensive analysis and actionable insights for design.

This study incorporates interdisciplinary collaboration, which brings diverse expertise that enriches the study's methodology and ensures relevance to both educational and design fields. Another advantage was conducting this study in an actual classroom setting, which provided practical and actionable insights relatable to real-world applications, specifically for ASD students. And finally, using the inCLASS tool ensured reliability in behavioral assessment as it's a validated assessment measure.

However, this study is not without challenges. The limitation of this study was the small number of participants. This limits the generalizability of results. As with any field study, ensuring consistency in other environmental factors (e.g., noise, temperature, and classroom activities) posed challenges. Additionally, the teacher's management style might have influenced results, complicating the isolation of lighting effects. However, this study highlighted the importance of collaboration, practical application, and careful variable management, offering valuable insights despite challenges.

## RESULTS

Results showed no significant overall differences in student behavior across CCT levels ( $p = 0.115$ ). However, student-teacher interaction significantly increased under higher CCT levels ( $p = 0.001$ ), indicating students displayed greater engagement with teachers in the presence of blue light. Peer interaction and task engagement showed no notable changes.

This study revealed that varying levels of correlated color temperature (CCT) in classroom lighting did not significantly impact peer interactions or task engagement behaviors. However, higher CCT levels were associated with increased student-teacher interactions. Consistent with prior research, positive teacher-student interactions are often linked to improved academic performance. Although overall scores for student engagement behavior did not yield significant differences, the observed enhancement in teacher-student interactions aligns with this established pattern. A potential contributing factor could be the teacher's classroom management style, which prioritized positive reinforcement and encouragement over corrective measures. This approach likely fostered stronger teacher-student relationships, which may have influenced the study's outcomes.

This study highlights the nuanced impact of classroom lighting on ASD students' engagement, suggesting that higher CCT levels may support teacher-student interactions. These findings could inform lighting design standards in educational settings.

## KEY FINDINGS

- 1. Increased Student-Teacher Interactions at Higher CCT Levels:** Students with ASD showed significantly higher levels of interaction with teachers under higher CCT lighting (5000K), as indicated by a p-value of 0.001 for teacher interactions.
- 2. No Significant Impact on Peer Interactions or Task Engagement:** The study found no significant differences in peer interactions or task engagement behaviors between high (5000K) and low (3000K) CCT lighting levels.
- 3. Overall Behavior Unaffected by CCT Levels:** At a 5% level of significance, no significant impact was observed in overall student behaviors across different CCT levels ( $p$ -value = 0.115).
- 4. Influence of Teacher Management Style:** The teacher's emphasis on positive reinforcement and encouragement may have influenced the results, particularly the increase in teacher interactions, without similarly affecting peer or task engagement.
- 5. Potential Implications for Lighting Standards:** While the findings suggest benefits of higher CCT lighting for teacher-student interactions, they indicate no broad behavioral improvements, highlighting the need for further research to guide classroom lighting standards.

## IMPLICATIONS

- **Prioritize Adjustable Lighting:** Classrooms should be equipped with tunable LED lighting to allow flexibility in correlated color temperature (CCT), enabling customization to suit diverse student needs.
- **Incorporate Higher CCT Options:** Include lighting fixtures capable of achieving higher CCT levels (e.g., 5000K) to enhance teacher-student interactions, which may support engagement in instructional activities.
- **Design for Sensory Sensitivities:** Ensure classroom lighting minimizes glare and flicker, as ASD students are particularly sensitive to environmental stimuli, which can affect their learning and behavior.
- **Flexible Control Systems:** Install intuitive lighting controls that enable educators to easily adjust CCT and brightness based on specific classroom activities or individual student needs.
- **Test Lighting Prototypes:** Conduct lighting studies in classrooms with varying student demographics to validate the impact of lighting on engagement behaviors and optimize future designs.

## LESSONS LEARNED

This research project revealed several important lessons. A key insight is that classroom lighting alone does not influence student behavior. Instead, factors such as teacher management styles, classroom dynamics, and individual student characteristics potentially influence outcomes. Recognizing and accounting for these confounding variables is essential for future studies to produce more nuanced and reliable results.

Conducting research in real classroom settings underscored the practical implications of design choices. This approach reinforced the value of situational testing in design research and highlighted the potential of implementing tunable LED lighting systems in educational environments.

Designing spaces with adaptable lighting can better accommodate the diverse needs of students and the various activities that occur within a classroom.

The integration of expertise from various professionals was another critical takeaway. Addressing complex questions about environmental effects on behavior required a collaborative, interdisciplinary approach. Such teamwork yielded more comprehensive and actionable insights, demonstrating the strength of combining diverse perspectives.

Ultimately, this research highlights the importance of methodological rigor, interdisciplinary collaboration, and real-world applications in studies that aim to inform design practices, particularly for special populations. These implications will guide future efforts to design environments that enhance learning and well-being for all students, including those with ASD.

## CONCLUSION

This research underscores the powerful role that environmental factors, such as interior lighting, can play in shaping learning experiences, especially for students with sensory sensitivities, such as those with ASD. It highlights the importance of considering human-centered design principles in educational settings—not just focusing on aesthetics or energy efficiency but also on how the environment supports diverse learners. More broadly, research like this exemplifies the value of interdisciplinary collaboration, bridging fields such as education and design, to address complex real-world challenges. It also illustrates that even well-controlled studies have limitations, and that understanding context and individual differences is crucial.

For researchers in any field, embracing flexibility, remaining open to unexpected findings, and continually reflecting on methodology and assumptions can lead to richer insights and more impactful outcomes. Translating research findings into actionable design recommendations and influencing policy or standards is essential to ensure that academic work leads to tangible improvements in people's lives.

## ADDITIONAL RESOURCES

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## RESEARCH BIO

**Alana Pulay, PhD, NCIDQ, WELL AP, LEED AP**, is an Assistant Professor of Interior Design in the School of Design + Construction at Washington State University. Her research, teaching, and professional practice focus on human behavior within preK-12 public school environments. She earned her PhD in Design and the Human Environment from Oregon State University, where her research concentrated on the impact of elementary school classroom lighting on student behavior. Alana holds a bachelor's degree in interior design from The Ohio State University and a Master of Architecture with a specialization in Interior Design from the University of Nebraska. As an NCIDQ-certified, WELL, and LEED AP interior designer, she brings over sixteen years of experience working with architecture and engineering firms specializing in public K-12 school design.

**Dustin Saalman, PhD**, is NAC Architecture’s Director of Research and Experience Development (RED). His practice informs the human aspect of design by combining research in user experience, cognitive psychology, data analysis, and human factors. Dr. Saalman collaborates with design teams to consult on methodology and create pre-design observation strategies exploring student engagement and building efficacy. Developing comprehensive documents, he advances architectural understanding to deliver more responsive and effective buildings.

**Julie Allen, LC, LEED AP**, takes a creative approach to each project and enjoys integrating the art and science of light. Creating an impact through light in any space is a balancing act, and Julie works to harmonize the many needs that pertain to light. Julie has over 19 years of experience in lighting design, having worked at consultant engineering firms, as well as in her current position as an in-house lighting designer at NAC Architecture. NAC’s community-focused Just Cause is that the world can always be more humane. Light, as it relates to form, has an immeasurable impact on the way that architecture embodies beauty, purpose, and sustainability. She is passionate about understanding the connection between light and human health. Her experience spans all project phases, from planning through construction administration and commissioning, and she has broad experience in many project delivery methods.

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