

DAYLIGHTING *initiative*

Design tools and information from The Pacific Gas and Electric Company

Daylighting in Schools ***An Investigation into the Relationship Between*** ***Daylighting and Human Performance***

Condensed Report

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on behalf of the
California Board for Energy Efficiency Third Party Program

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EXECUTIVE SUMMARY

This study looks at the effect of daylighting on human performance. It includes a focus on skylighting as a way to isolate illumination effects from other qualities associated with daylighting from windows, such as view and ventilation. In this project, we established a statistically compelling connection between daylighting and student performance, and between skylighting and retail sales. This report focuses on the school analysis.

We obtained student performance data from three elementary school districts and looked for a correlation to the amount of daylight provided by each student's classroom environment. We used data from second through fifth grade students in elementary schools for two reasons: because there is extensive data available from highly standardized tests administered to these students, and because elementary school students are generally assigned to one teacher in one classroom for the school year. Thus, we reasoned that if the physical environment does indeed have an effect on student performance, we would be mostly likely to be able to establish such a correlation by looking at the performance of elementary school students.

We analyzed test score results for over 21,000 students from the three districts, located in Orange County, California, Seattle, Washington, and Fort Collins, Colorado. The data sets included information about student demographic characteristics and participation in special school programs. We reviewed architectural plans, aerial photographs and maintenance records and visited a sample of the schools in each district to classify the daylighting conditions in over 2000 classrooms. Each classroom was assigned a series of codes on a simple 0-5 scale indicating the size and tint of its windows, the presence and type of any skylighting, and the overall amount of daylight expected.

The study used multivariate linear regression analysis to control for other influences on student performance. Regressions were compared using data from two separate tests, math and reading, for each district. Each math and reading model was also run separately using first the window and skylight codes, and then the overall daylight code. We reasoned that if daylight effects were truly robust the variables should perform similarly in all models. Thus, we created a total of twelve models for comparison, consisting of four models for each of three districts.

The daylighting conditions at the Capistrano school district were the most diverse, and the data from that district were also the most detailed. Thus Capistrano became our most precise model. In this district, we were able to study the change in student test scores over a school year. Controlling for all other influences, we found that students with the most daylighting in their classrooms progressed 20% faster on math tests and 26% on reading tests in one year than those with the least. Similarly, students in classrooms with the largest window areas were found to progress 15% faster in math and 23% faster in reading than

those with the least. And students that had a well-designed skylight in their room, one that diffused the daylight throughout the room and which allowed teachers to control the amount of daylight entering the room, also improved 19-20% faster than those students without a skylight. We also identified another window-related effect, in that students in classrooms where windows could be opened were found to progress 7-8% faster than those in rooms with fixed windows. This occurred regardless of whether the classroom also had air conditioning. These effects were all observed with 99% statistical certainty.

The studies in Seattle and Fort Collins used the final scores on math and reading tests at the end of the school year, rather than the amount of change from the beginning of the year. In both of these districts we also found positive, and highly significant, effects for daylighting. Students in classrooms with the most daylighting were found to have 7% to 18% higher scores than those in rooms with the least.

The three districts have different curricula and teaching styles, different school building designs and very different climates. Yet the results of the studies show consistently positive and highly significant effects. This consistency supports the proposition that there is a valid and predictable effect of daylighting on student performance.

The results of this study of student performance, when considered along with those of the companion study showing the positive effect of skylighting on retail sales, also strongly support the thesis that these performance benefits from daylighting can be translated to other building types and human activities.