Working designs : research provides hard evidence to confirm that giving workers control over their own lighting can benefit the employer's bottom line

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Publisher's version / Version de l'éditeur:

Canadian Consulting Engineer, 40, Aug/Sept 5, p. 70, 73, 1999-08-01

RÉSUMÉ

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Working designs

Research provides hard evidence to confirm that giving workers control over their own lighting can benefit the employer's bottom line.

Lighting design affects office worker performance and satisfaction, according to two recently completed studies by the Institute for Research in Construction (IRC) at the National Research Council. The research also found that giving occupants control over lighting leads to energy efficiency.

Both studies were performed in IRC's Indoor Environment Research Facility which is a controlled space dedicated to the study of the indoor environment and its effects on occupants. The 90-m2 area was configured as a windowless, open-plan office containing six work stations of around six square metres each. For both studies, temporary office workers were hired to work in the space for a day, performing standardized, computer-based tasks and completing questionnaires on topics such as environmental satisfaction, mood, and physical comfort.

In the first study, lighting designers created a variety of lighting designs for the research facility. The designs varied in energy consumption, with some designs at current energy code levels for offices, some above energy code levels, and some below. The designs also varied in luminaire type, with some featuring direct ambient lighting with prismatic lenses, others with parabolic louvers, and others with a substantial indirect component. All designs were legitimate designs for space with computers, and used off-the-shelf light fixtures. The lowest energy designs had low ambient lighting levels with supplementary task lighting. The higher energy designs, which represent the practice of the past but which are still installed in many buildings, featured magnetic ballasts.

Groups of at least 30 participants experienced each design. Statistical analysis of the performance and questionnaire data revealed consistent and important differences between the categories of lighting design.

Electronic vs. magnetic ballasts

All the systems with electronic ballasts, for example, were compared to all systems with magnetic ballasts. While there were statistically significant outcomes favouring both ballast types, the preponderance favoured electronic ballasts. For example, amongst other effects,

Two of the nine lighting designs tested.

occupants who were experiencing designs using electronic ballasts typed 21% faster during a creative writing task than those who were experiencing designs using magnetic ballasts. Further, on a reaction time task, occupants experiencing designs using electronic ballasts responded 8% quicker.

Previous studies have shown that electronic ballasts lower the incidence of headaches and eyestrain. The most likely cause is their much higher operational frequency 20KHz as opposed to 120 Hz in magnetic ballasts. Therefore, not only are electronic ballasts more energy efficient than magnetic ballasts, they are better for people and their task performance their higher cost seems justifiable.

Task lighting and louvers

Another effect was a preference for systems with task lighting. This is also good news for energy efficiency because the systems with task lighting had lower power. Occupants with task lighting had significantly higher ratings of satisfaction with lighting than occupants without task lighting; they also had significantly lower ratings of glare.

These results are confounded by the fact that the systems with task lighting generally had lower levels of illumination: we don't know if the effects are due to preferences for task lighting itself, or to lower illumination levels. However, we can say that, for the systems we investigated, systems with task lighting and lower ambient light

levels were a way of realizing lower energy designs that were rated highly by occupants.

We also found that for designs with direct lighting there was a preference for parabolic louvers over prismatic lenses. Workers under parabolic lenses rated their own productivity as 8% higher that those occupants working under prismatic lenses. They also had significantly lower ratings of general task difficulty and glare.

Preferences and profits

In the second study, two participants occupied the research facility on any given day. Data was collected for 94 participants. The facility featured a hybrid lighting system, with multiple fixtures on four controllable circuits. One circuit controlled an under-shelf task light, a second circuit controlled partition-mounted indirect fixtures, a third circuit controlled recessed parabolic fixtures directly overhead, and the fourth circuit controlled recessed parabolic fixtures at the perimeter of the room. The task light had on-off control, whereas the other fixtures were continuously dimmable. On each day, one participant had control at the start of the day, with the second participant getting control at the end of the day. During the day participants completed computer-based tasks and questionnaires.

One interesting outcome was the lighting that people chose for themselves. Most participants 78 % chose desktop illuminance levels lower than 500 lux. At the end of the day (after prolonged experience in the room), participants chose to lower the output of the perimeter recessed fixtures in an attempt to reduce reflected glare on the computer screen. These findings support IESNA RP-1 "American National Standard Practice for Office Lighting." Further, around 90% of the participants chose to use task lighting, supporting the preference indicated in our first study.

Another encouraging finding for energy efficiency is that the power draw of participants' lighting choices averaged 14.4 W/m2, 10%-20% lower than the upper limit allowed by the National Energy Code for Buildings. Rather than leading to profligacy, individual control might be an energy reduction strategy.

The results of our research show that office lighting design does affect occupant satisfaction and performance, and that appropriate lighting designs and controls can both meet occupants' needs and save energy. These conclusions suggest that investing in office lighting design can be objectively justified.

Drs. Guy Newsham and Jennifer Veitch are in the Indoor Environment Program of the NRC's Institute for Research in Construction in Ottawa. For more information, see: http://www.nrc.ca/irc/light/