ILLUMINATING LILLIS:
LIGHT LEVELS AND PATTERNS OF USE OF THE DAYLIGHT INTEGRATED LIGHTING SYSTEMS IN THE LILLIS BUSINESS COMPLEX

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ABSTRACT

Due to accounts of frustrated instructors overriding the lighting systems in the classrooms of the Lillis Business Complex at the University of Oregon, we hypothesized that the daylight integrated lighting systems were not functioning according to the design intentions.

We investigated how the lighting systems operate and if, in fact, they perform as intended. We first collected illumination levels with light meters while the lights were both on and off in two North- and two South-facing classrooms. We then analyzed patterns of use from relative illuminance data collected over the course of one week from Hobo data-loggers in each room.

Our findings reveal that although the daylight integrated lighting systems are not consistently providing the target illuminations for which they were designed, they still provide acceptable illumination levels according to the standards published by Illuminating Engineering Society of North America (IESNA). We also found that the patterns of use are in keeping with the classroom occupation schedule. Furthermore, it appears that the preset lighting conditions are being used and the system controls are not being overridden as originally believed.

1. INTRODUCTION

The basis of design for the new Lillis Business Complex for The Charles H. Lundquist College of Business was to create a sustainable building that was representative of the values held by both the College and the University of Oregon. Included among the objectives of design was the integration of daylight to reduce energy consumption and provide a refreshing, stimulating learning environment.

During an introductory tour of Lillis, we heard about instructors becoming either frustrated or confused with the lighting control systems in the classrooms. Assuming that the instructors were overriding the lighting control systems, we became intrigued with their operation, controls, and user interface.

The classrooms are illuminated by a daylight integrated lighting system, which was designed to provide approximately 30 footcandles (fc) at desktop height under the “Lecture 1” preset.

When a user pushes the “on” button for the classroom lights, the automatic shades open to let in daylight, and the electric lights turn on at 50% illumination and adjust according to the amount of light received by photo sensors located in the dropped ceiling.

Four preset lighting conditions are provided for the user: “Lecture 1,” “Lecture 2,” “Projector 1,” and “Projector 2.” While under the preset conditions, the system continues to automatically respond to daylight levels. However, if the shade position or individual lighting zones (“wall wash,” “audience,” “board,” and “screen”) are manually adjusted, the system is overridden and will no longer automatically adjust according to available daylight.

The lighting systems are separated into three different light gradients moving away from the windows.

One difference to note between the South- and North-facing classrooms is the fact that the South classrooms have light shelves to bring more daylight into the rooms.

2. HYPOTHESIS

Given our understanding of the daylight integrated lighting system, we developed a series of questions upon which to base our study. The questions were derived from our curiosity about the quality of light in the classrooms as well as the users' interaction with the system. The questions we developed were as follows:

- What were the design intentions?
- Are lighting levels substantial for tasks when the electric lights are on or off?
- When lights are turned on, do they adjust according to the amount of daylight?
- Do the electric lights adjust to proper levels according to IESNA?
- Do the electric lighting systems in the North and South classrooms function differently?
- Are the system settings appropriate to the different daylighting levels in the North and South classrooms?
- Are the system controls being overridden?

These inquiry questions led us to hypothesize that *the daylight integrated lighting systems in the classrooms of the Lillis Business Complex do not provide 30 foot candles at desk level per the design intentions.*

This hypothesis allowed us to pursue our investigation by conducting two separate, but closely related, studies. One study examined the illuminance levels at desk-top height under preset "Lecture 1" and with the lights off, and a second study studied the patterns of use in the classrooms over the course of a week.

3. METHODOLOGY

We chose four classrooms in which to conduct our study: two North-facing (Rooms 162 and 262) and two South-facing (Rooms 185 and 285) classrooms. These classrooms are representative of the variety of classrooms in Lillis.

3.1 Illumination Levels

We conducted the illuminance study by first marking a five foot grid throughout the room. At these different points we took light level measurements at desk-top height using a Sylvania Light Meter. We took readings with both the lights on (under preset Lecture 1) and the lights off. The "Lights On" readings gave us a picture of the light distribution throughout the room while the electric lights are responding to daylight conditions. The "Lights Off" readings allowed us to measure the Daylight Factor in the classrooms. After collecting this data we compared our results with the design intentions and with IESNA illumination standards.

3.2 Patterns of Use

In order to represent the lighting activity over the course of one week, we used Hobo brand data-loggers to measure relative changes in illuminance intensity. Because the lighting fixtures in the classrooms are divided up into three gradient zones we used three data-loggers in each room. We attempted to reduce the influence of daylight on the data collected by suspending the data-loggers two inches from the light source. After collecting this data we compared it with the classroom usage schedules. This allowed us to determine if the lights were turning on while the rooms were unused. In order to determine how the professors used the system, we again installed the data-loggers in one room and carefully recorded how we manipulated the lights. This aided us in our analysis of the gathered data. It also allowed us to interpret the graphical representation of that information.

4. RESULTS

4.1 Illumination Levels

The following illumination maps, for a North (see *fig. 4a*) and a South-facing (see *fig. 4b*) classroom, were taken during the same afternoon and demonstrate the different daylight penetrations depending on orientation.

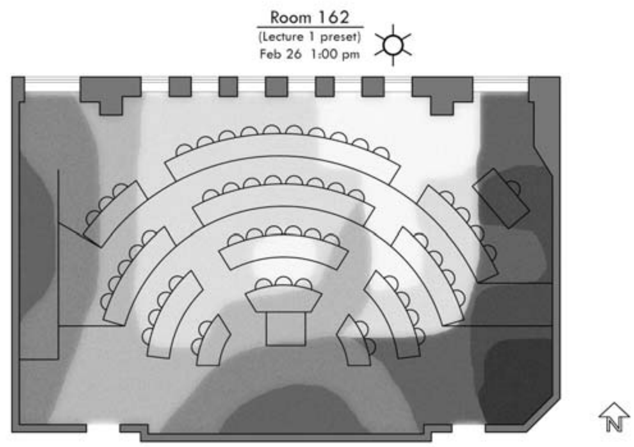


fig. 4a. Illumination map for Room 162. (See key below)

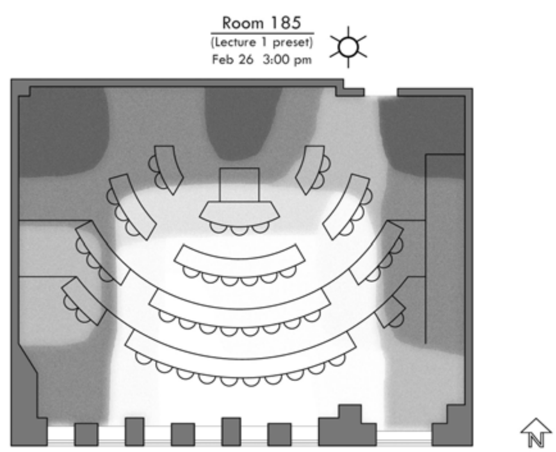


fig. 4b. Illumination map for Room 185. (See key below)

The following diagrams show the distribution of daylight in section throughout a North (see *fig. 4c*) and a South-facing classroom (see *fig. 4d*). These readings were taken during the same afternoon and demonstrate the different daylight penetrations depending on orientation. This study was beneficial because we were able to judge how effectively daylight was penetrating the spaces. This data also shows that daylight affects the light conditions at all desks, but not the instructor's podium, in both classrooms.

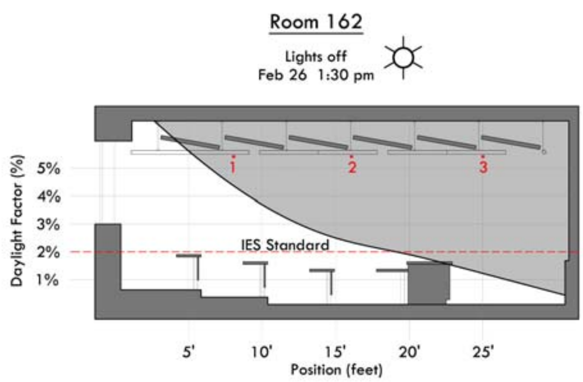


fig.4c. Daylight Factor section diagram for Room 162.

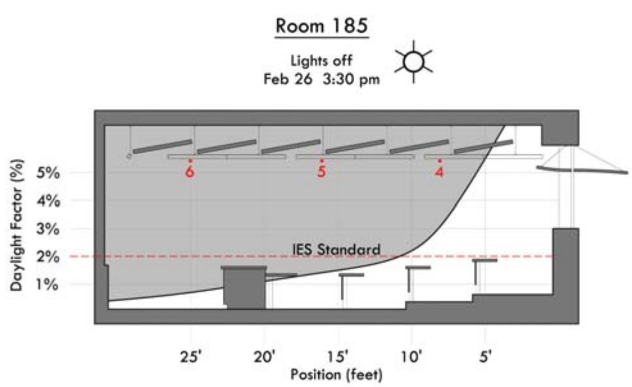


fig. 4d. Daylight Factor section diagram for Room 185.

4.2 Patterns of Use

The following graphs provide information that is useful for observing the overall patterns of use of the daylight integrated lighting system (see *fig. 4e*). One can determine whether or not the lights are turning on at inappropriate times, i.e. when class is not in session, or after the building is closed.

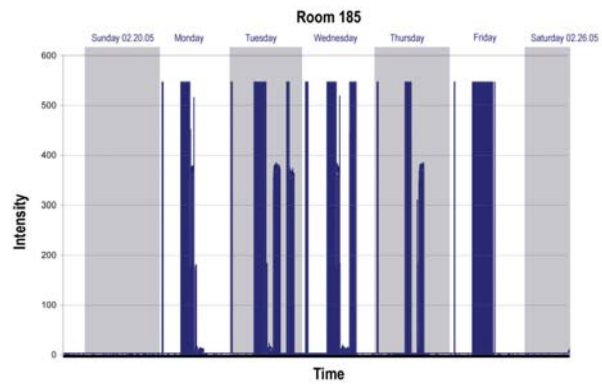


fig 4e. Data collected over entire week for Room 185.

The following graph of a typical day in Room 185 shows the lighting activity while classes are being conducted (see *fig. 4f*). The shaded areas represent different classes that are scheduled for this room on the given day.

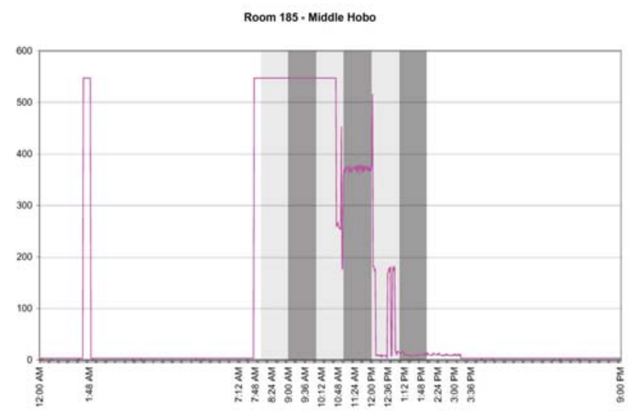


fig. 4f. Data collected over one day for Room 185.

5. <u>ANALYSIS</u>

5.1 <u>Illumination Levels</u>

The illumination data we gathered shows that the design goal of 30 fc is not being consistently met. The desk-top height illumination levels ranged from 20-50 fc. However, after comparing this data to standards published by the IESNA, we find that the levels fall into the acceptable illumination range (20-50 fc) for the space and required task (information from Table 18.7, MEEB, 9^{th} ed.). The following diagrams show analysis of a North (see *fig. 5a*) and a South-facing classroom (see *fig. 5b*).

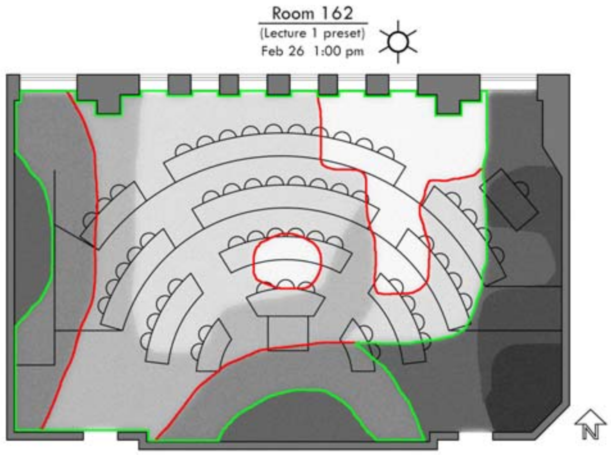


fig. 5a. Illumination map for Room 162. (See key below)

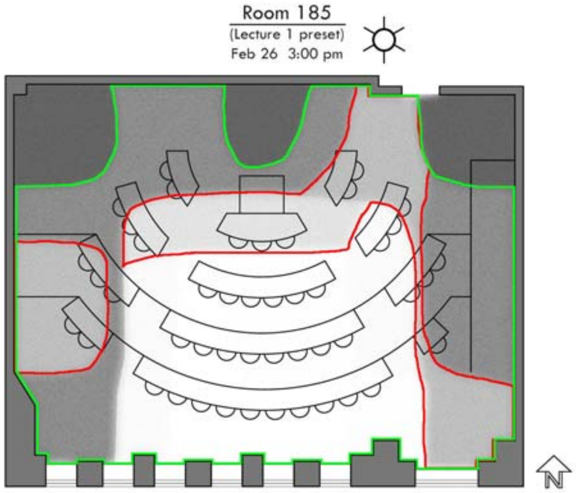
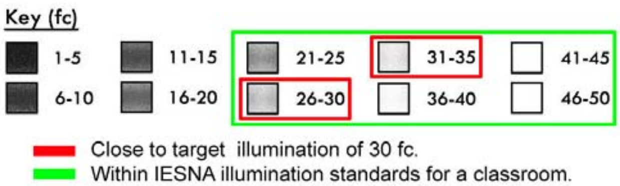


fig. 5b. Illumination map for Room 185. (See key below)



5.2 Patterns of Use

Fig. 4e shows that the lighting system is not turning on at inappropriate times of the day or night. The graph shows that the lights turn on for a brief time during the early morning, but this is when the cleaning staff is in the room. Otherwise, the lights are only on during the school day, when the doors are unlocked.

In order to further analyze the data collected we needed to create graphical information based on monitored manipulation of the lighting system (see *fig. 5c*). With this information we were able to look at the data collected by the Hobo data-loggers and interpret whether the system presets were being used and, if so, which ones.

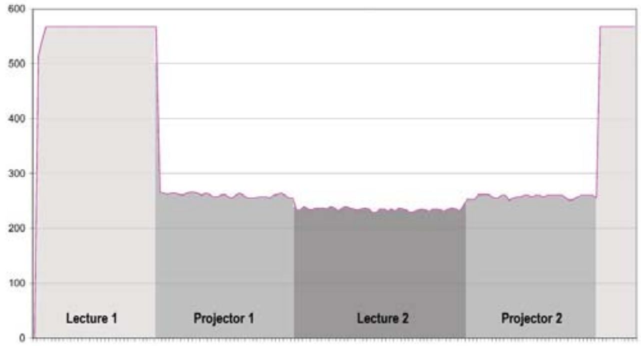


fig. 5c. Comparison data collected showing the graphical representations of the various presets.

Gathering this data allowed us to clearly see from the graphs that the preset lighting conditions were being utilized. In addition, we blocked out the class times on the daily activity graphs. This, in combination with the test data showed us which presets were used during specific classes throughout the day (see *fig. 5d*).

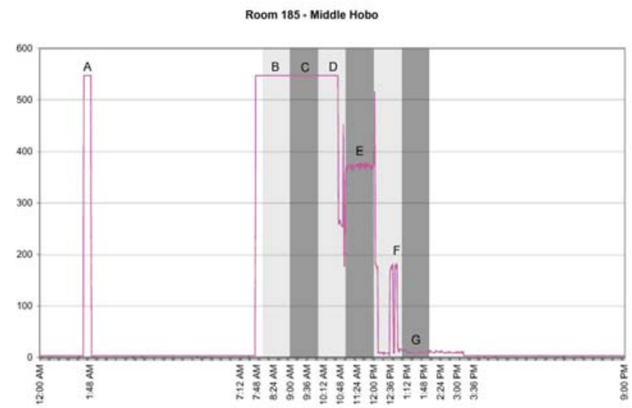


fig. 5d. Daily activity graph showing class times and predicted preset usage. A) Lecture 1 [cleaning service], B) Lecture 1, C) Lecture 1, D) Lecture 1 and a Projector preset, E) Dimmed Lecture 1, F) Activity unclear, G) Lights possibly off.

6. CONCLUSIONS

6.1 Illumination Levels

Based on the data we gathered, the design intentions are not being consistently met, thus proving our hypothesis. However, in comparison to published standards, the measured illumination levels are still within a desirable range for a classroom environment.

6.2 Patterns of Use

Based on the data gathered, we can determine that the lighting systems are not turning on at unexpected times of the day or night. We can also conclude that the electric lighting presets are being used throughout the class periods.

For future studies, we recommend studying illumination levels for the other presets: Lecture 2, Projector 1, and Projector 2. A study of the Lighting Power Density would inform us about the efficiency of the daylight integrated lighting system. We also suggest conducting the Patterns of Use study in conjunction with instructor interviews to help determine their use and perception of the lighting system. Additionally, the Patterns of Use study could be followed with more in-depth analysis of the data and compared to direct observation to help interpret graphical data collected. As *fig. 5d* shows, there is some lighting activity that we were unable to interpret. Future studies would hopefully explain the graphical representation of these activities.

Improvements in methodology for future studies include using a more accurate light meter (Minolta, Li-Cor or Ex-tech), taking illumination measurements on a smaller grid (one foot), and using more Hobo data-loggers to record data (six total on each light strip—two for each gradient zone). Additionally, we recommend conducting instructor interviews to provide more insight into the Patterns of Use study. Also, direct observation of lighting system use during class times would be helpful.

7. REFERENCES

1. J.S. Reynolds and B. Stein, Mechanical and Electrical Equipment for Buildings, 9th Edition, John Wiley & Sons, Inc: New York, 2000.

8. ACKNOWLEDGMENTS

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