VITAL SIGNS

A BALL STATE UNIVERSITY CASE STUDY IN LIGHTING

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Fig. 1 *view of southern facade of the Alumni Center*

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ABSTRACT:

This report presents findings from a three-month case study of the library in the Ball State University Alumni Center. We chose to study the illuminance and luminance levels in the space, hypothesizing that the lighting conditions, both electrical and day-lighting, are inappropriate for the activities typically performed in the room. To test our theory and gather numerical illuminance and luminance data, we executed a series of tests using: hobo light intensity meters to find how illuminance levels varied throughout the day, hand-held light meters to spot-check illuminance levels at each table surface, a luminance gun to compare illuminance with luminance at each table surface, AutoCAD to simulate light patterns and distribution throughout the room, and occupancy meters to correlate library occupancy with the lighting atmosphere at the corresponding times. We interviewed the building manager, Matt Stevenson, to learn for what purposes the room is used. We spent time in the library performing typical activities and visual tasks to formulate our own evaluations of visual comfort. We found low levels of illuminance appeared to be evenly distributed throughout the room except in the solar radiation that penetrated in the spaces between the louvers of the west doors; there we found extremely high illuminance levels.

Fig. 2 *Interior panoramic showing spatial organization*

INTRODUCTION:

The Vital Signs Project is a curriculum development endeavor funded by the Energy Foundation, Pacific Gas & Electric, and the National Science Foundation. It is coordinated via the Center for Environmental Design Research at the University of California at Berkeley. The Vital Signs Project is designed to integrate interdisciplinary students in an effort to teach them how to research and investigate a hypothesis, then create a detailed technical report. All work is done under the direction and advice of architecture faculty and professional staff in CERES as well as nationally recognized architectural experts, who give guest lectures to the students and critique their work. Students are grouped into teams and choose a case study of conditions in existing buildings - in this case, the lighting conditions of the library space in the Alumni Center at Ball State University.

James Freed of Pei, Cobb, Freed and Partners, an internationally renowned architectural firm, designed the Alumni Center. It is a multilevel "brick" masonry, limestone, and metal clad building, with a triangle and hexagonal plan layout, surrounding a forty-seven foot glass conservatory. Features include a major assembly hall capable of seating up to four hundred and eighty people, a boardroom, small conference meeting rooms for formal or informal meetings or events, a spacious reception area, a library with displays of alumni memorabilia, and administrative offices for the Alumni Association, University Development, University Relations, and the University Foundation.

The library, originally designated as a lounge, is furnished with couches and comfortable chairs for relaxing as well as two circular tables with straight-backed chairs intended for business purposes. Other features of the room include electrically lit display shelves, a large-screen television, a well-equipped pantry, wooden doors that lead outside to the west and south, and a large gas fireplace. A large screen-shaded window to the south and doors with louvres allow daylight into the room. Electrical light comes from an indirect overhead light in a hexagonal light cove and from high-intensity, low-voltage, halogen accent lights, which are near the display shelves and in a circular pattern in the center of the ceiling. The operational panel located in the pantry controls the electrical lighting atmosphere.

We interviewed the building manager of the Alumni Center, Matt Stevenson. It proved somewhat helpful in that we gained a better idea of the activities performed in the room. Mr. Stevenson informed us that events are not often scheduled there, so that the room is kept available for casual use. Events that are scheduled for the room include luncheons, receptions, and small conferences for university organizations. He mentioned that President Worthen and a few colleagues often use the room for discussions. The library lights are turned on every day at seven a.m. and shut off in the evenings at approximately five p.m, unless an event is taking place. He stated the light scheme is almost always on "house full". This interview gave us better insight regarding the intended lighting scheme for the room's uses.

HYPOTHESIS:

The lighting conditions, both electrical and day-lighting, are inappropriate for the activities typically performed in the library space.

Lighting Conditions Include:
Illuminance, luminance, brightness, glare, and veiling reflections
Activities Typically Performed Include:
Group conferences, one-on-one interaction, reading, display case observation, and temporary display observation.

Our evaluation criteria are based on both IES standards and perceived visual comfort.

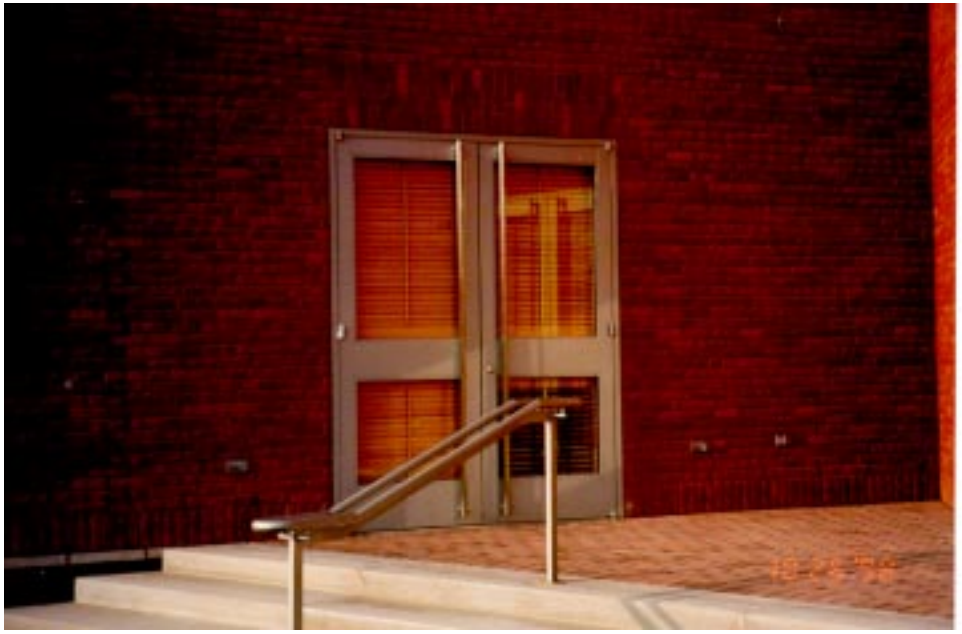

Fig. 3 *one of two typical exterior doors showing:*
louvres
opportunity for daylight

Fig. 4 *exterior window of library showing:*
sunshades
relative size of shades to window

METHODOLOGY:

To test our hypothesis, we followed a systematic procedure to evaluate the effects of light in the library. The procedure included collection of raw data, observation of how light patterns in the room affected the displays, and evaluation of the occupancy of the room during various times of day and the visual comfort during those times. Then we compared the results to standards set by the Illumination Engineering Society.

First, we gathered illumination information during various times throughout the day at fifteen and thirty-inch high work planes, the heights of the coffee and work tables, respectively. We used illuminance data in footcandles from the hand-held Model DS-2000 Sylvania light meter to create isolux contour maps of the room. We compared the acquired data to IES standards. Secondly, we created a three-dimensional digital model of the environment and used the results to analyze the conditions within the space.

Next, we evaluated how light patterns in the room fell upon the free-standing and permanent displays in the room. We took photographs of both the freestanding displays and the items in the glass panel display cases. We applied Photoshop to show areas of high light contrast. We looked for situations of indirect glare reflected on the glass panels of the display cases.

To determine how the collected data relates to the use of the room, we gathered information regarding the visual comfort and compared it with the purpose of the room and the frequency of its use. Visual comfort was evaluated by finding areas of high contrast from the photographs altered by Photoshop, then observing these situations ourselves. We engaged in activities typical of the library to observe the appropriateness of the lighting conditions during various times of the day. We placed a Radio Shack occupancy sensor near the entrance of the library to discover when the room was occupied, then compared these findings with the recorded lighting conditions at the corresponding times.

Fig. 5 Photo of interior space

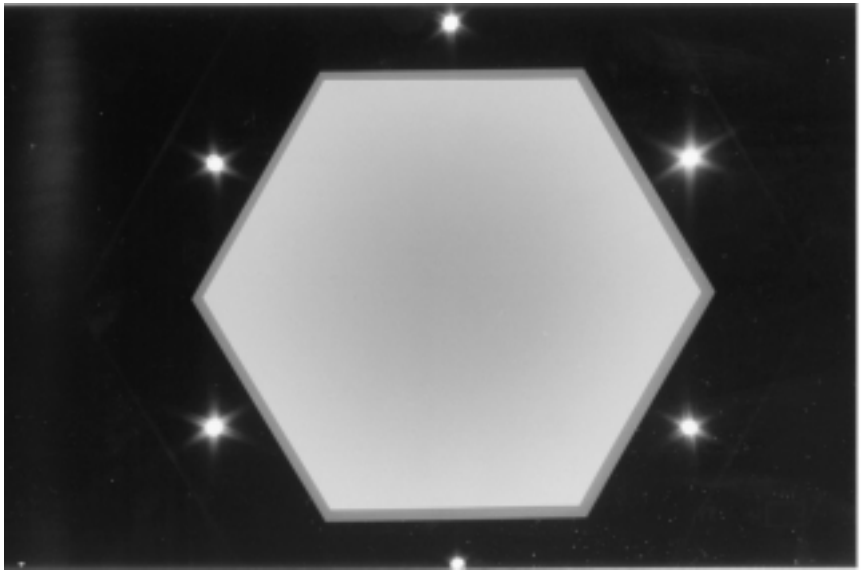

Fig. 6 Photo of overhead lightwell

FINDINGS AND ANALYSIS:

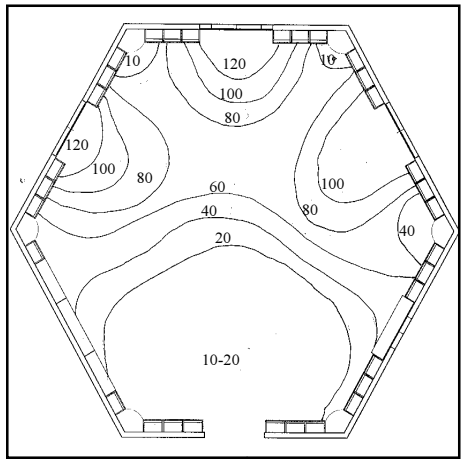

Fig. 7 *readings at 11:45 am*

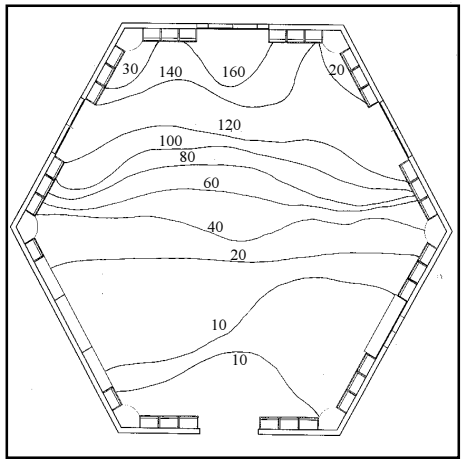

Fig. 8 *readings at 4:00 pm*

contour map of library at 30 inches above floor

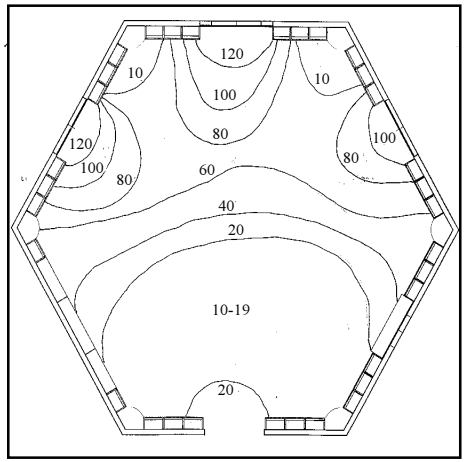

Fig. 9 *readings at 11:45 am*

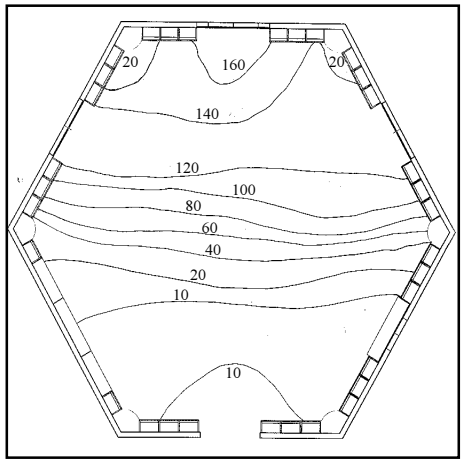

Fig. 10 *readings at 4:00 pm*

contour map of library at 15 inches above floor

Our contour maps show higher levels of illuminance in areas closest to the daylight sources: the window and both double doors, which have glass that allows daylight to enter the room. In all four figures, the lowest levels of illuminance were found in the north half of the room.

We took readings at 11:45 a.m. and 4:00 p.m. to note the effects of the sun at different times of the day. Our analysis divides the information into two categories based on the two areas where work may be performed: the lounge area including the coffee tables, which are fifteen inches above the floor, and the work area including the work tables, which are thirty inches above the floor.

For purposes of analysis, we referred to the north half of the room as the lounge area and the south half as the work area. The lounge area with couches and end tables is adequately lit for short visits and occasional visual tasks. IES standards call for 5-10 footcandles for short visits and 10-20 footcandles for occasional visual tasks; we found that the illuminances for this area ranged from 10-60 footcandles (see figures 9 and 10). The work area, containing two large work tables, is adequately lit according to the IES standards (see Appendix C) for areas where visual tasks of high or medium contrast are performed. IES standards call for 20-50 footcandles for visual tasks of high contrast and 50-100 footcandles for visual tasks of medium contrast. We found that both work tables had illuminance levels of 60 and 120 footcandles at 11:45 a.m. and 4:00 p.m., respectively (see figures 7 and 8). However, on October 27, an overcast day (see Appendix D), illumination on the two work tables was severely inadequate.

From this we can infer that the lounge furniture and the work tables are well-placed according to the light levels in their respective areas. However, as a result of our experiences in the room, we were led to believe that the visual discomfort we felt when engaged in casual reading could be attributed to factors other than illumination. Such factors are possibly high levels of contrast and glare.

FINDINGS AND ANALYSIS:

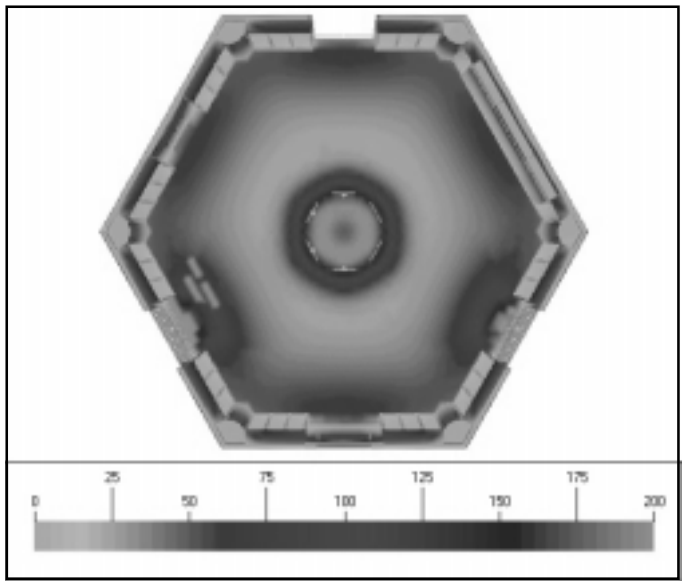

Fig. 11 (fc) light simulation at 30 inches above floor

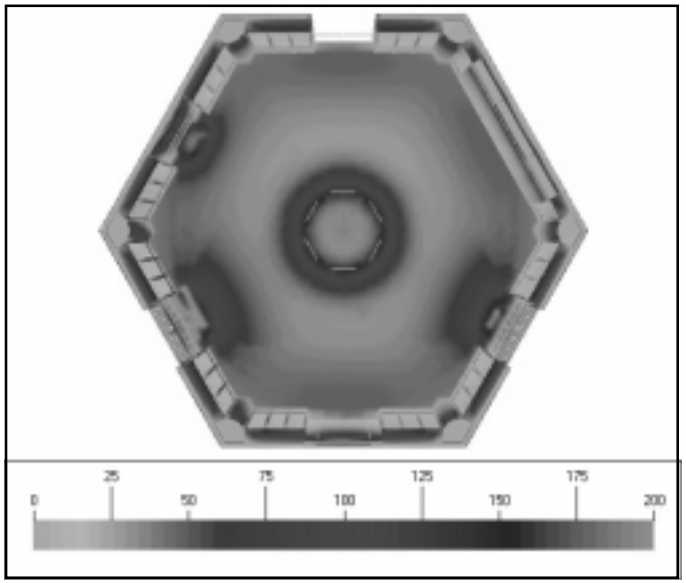

Fig. 12 (fc) light simulation at 15 inches above floor

A digital model was used to simulate lighting conditions within the space. Using AutoCAD, the industry standard in computer aided design (CAD) software, and the AccuRender lighting and rendering package , the materials and lighting conditions were digitized and plotted. In analyzing this information, a general trend can be established. Although there seems to be a sufficient amount of light in the space, it is focused on non-task oriented areas. The center light well and halogen can lights direct a beam of light onto the floor in the center of the room (figs. 11 and 12). Unfortunately, no activities needing a direct, high-intensity lighting condition take place here. The southern exposure also results in large, unwanted amounts of light on the floor in front of the two exterior doorways and window. This results in a large amount of glare at the times when the sun's azmuth is low (fig 13). It is also plain to see why a limited amount of light enters the display lower tiers of the display shelves (fig 14). The angle of light from the overhead fluorescent tubes is much too acute to reach the rear of the display.

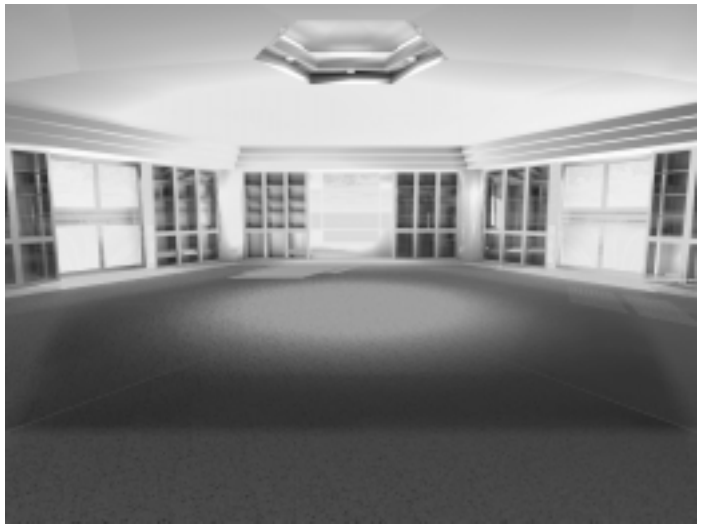

Fig. 13 Rendering of interior space

Fig. 14 Cut away showing display cases lighting

FINDINGS AND ANALYSIS:

We placed an infrared occupancy sensor to learn when there was movement in the room. It was under the sofa between the door and the television so it could detect the movement of feet. This particular type of occupancy sensor was used in combination with a StowAway voltage intensity logger. The sensor emits a voltage of electricity that dissipates over time (see Appendix D). The logger records this voltage at 3 minute intervals. The resulting graphs show the amount of remaining charge at the time of logging. Therefore, the graphs show only times when voltage was detected and the intensity of that voltage is relative to the amount of time passed since the movement was detected. We learned from Matt Stevenson that the Alumni Center hosted an Emeriti Conference on November 19th, accounting for the increase in activity within the room on that day. These retired faculty were very interested in the memorabilia contained within the display cases. The lighting levels were also taken from the window sill on these two days. Comparing these two graphs, shows that occupancy is not determined by the amount of light within the space.

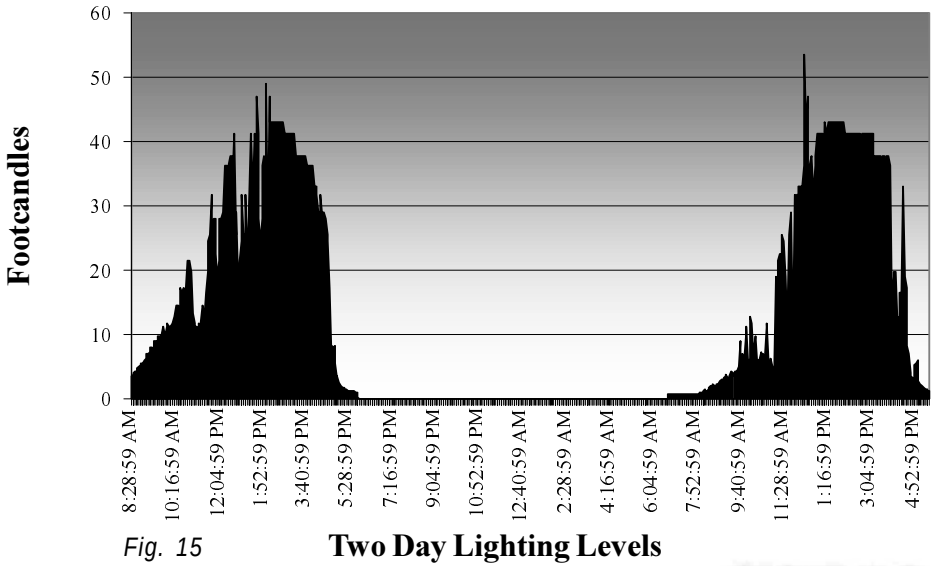

Fig. 15

November 19, 1998

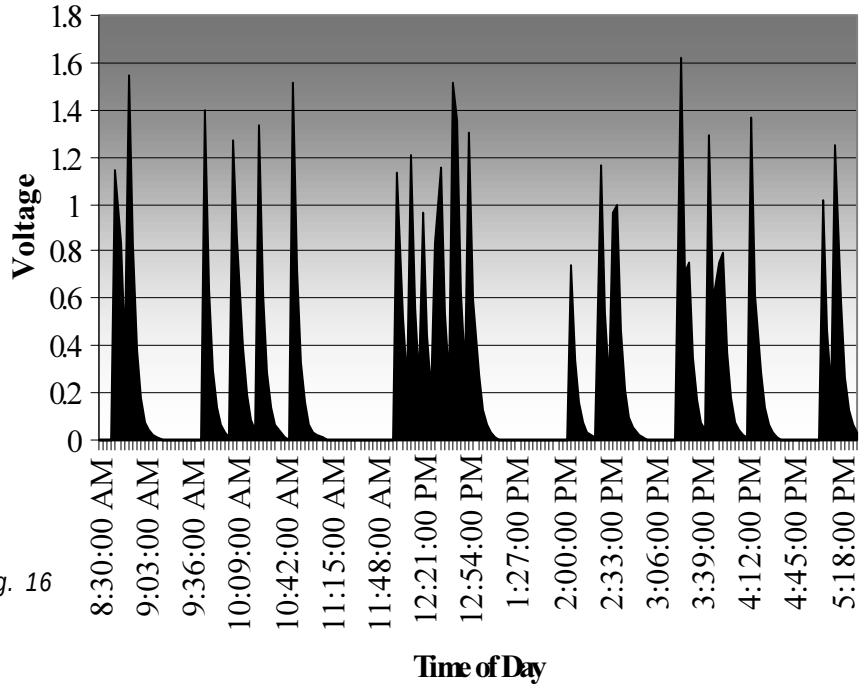

Fig. 16

November 20, 1998

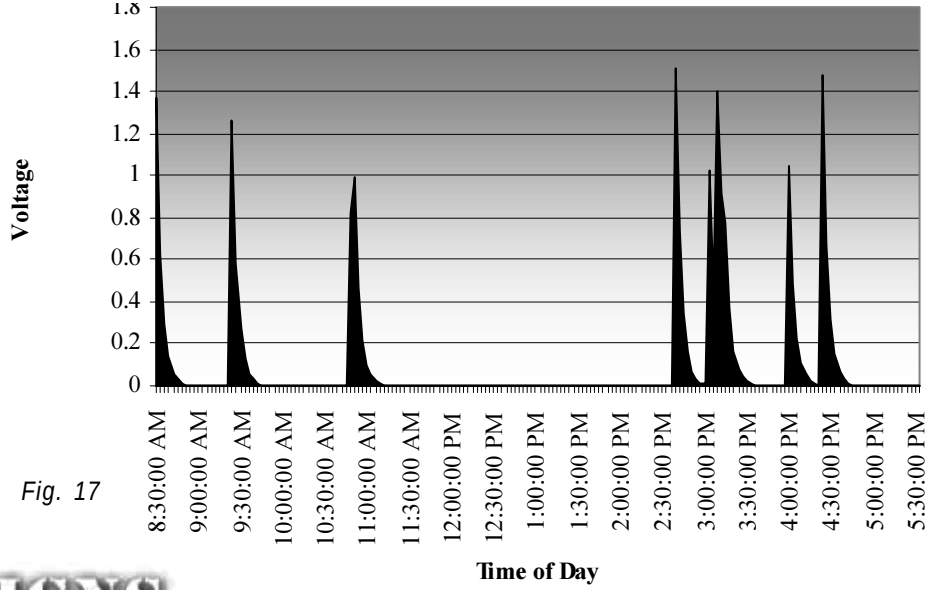

Fig. 17

FINDINGS AND ANALYSIS:

Temporary Display Testing:

Fig. 18 *original photograph*

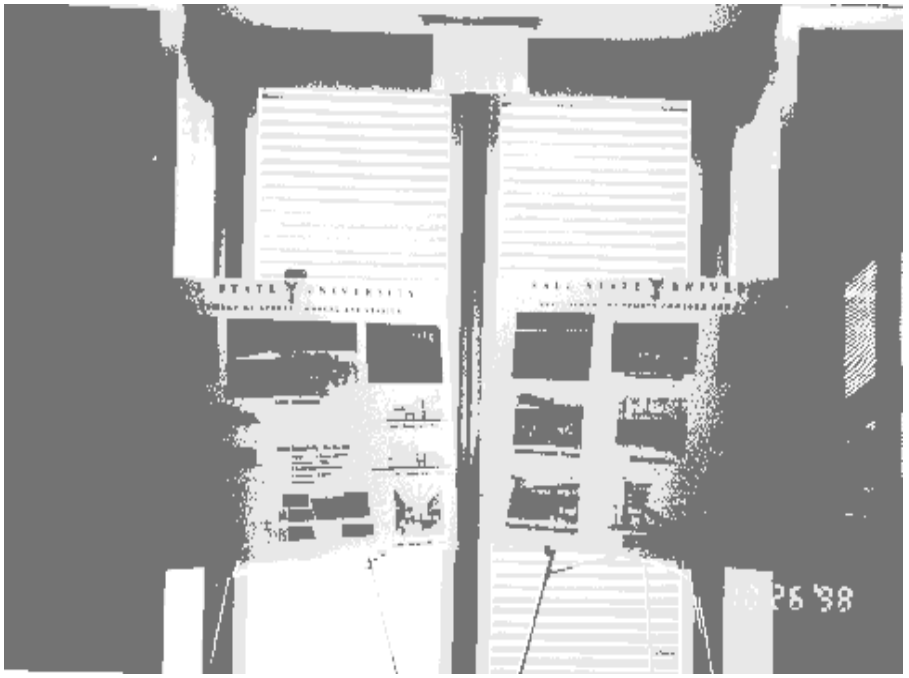

Fig. 19 *PhotoShop enhanced with readings*

The original photograph (fig. 18) shows the placement of the movable stands used for displaying architectural renderings of campus buildings. Every time we visited the room, these stands were placed in front of one of the two sets of double doors. Figure 19 shows the original photograph after it has been enhanced in Photoshop to further accentuate the contrast between darker and lighter areas in the field of view. These photographs were taken for the purpose of evaluating the effectiveness of the lighting conditions and the clarity and readability of the displays. From these photos, it is plain to see that the brightest areas in the field of view are not on the displays; instead, the surrounding areas, especially the areas behind the displays, are brightest. Also, the light hitting the viewing surfaces of the displays is unevenly distributed. The portions of the displays closest to the center are much brighter than the outer edges. As a result, the drawings and text on the displays are not highlighted - they are barely legible because the eye cannot accommodate for the large amount of backlighting. The lighting conditions in this particular situation are inappropriate, but the problem results from improper placement on behalf of the users. No provisions were made in the room's design for temporary displays of this nature. Obviously, the architect and/or lighting designers never anticipated displays in this area for the simple reason that it is a path of egress.

FINDINGS AND ANALYSIS:

Permanent Display Cabinets:

Fig. 20 *original photograph*

Fig. 21 *PhotoShop enhanced with readings*

Figures 20 and 21 show one of the display cases which line much of the wall space in the library. When we observed the way the cases were lit, we learned some of them have small accent lights, but the majority do not. We found that the light does not reach the back of the display cases, which needs light for viewing purposes.

In figure 21, the lower left-hand corner demonstrates the problem with glare. Notice also the smaller area of glare in the lower right-hand corner. By studying the enhanced photo, we derived that the wooden paneling was receiving the most illuminance. The darkness and shadows inside the cases make it easier to create a glare or veiling reflection, and the lightness of the wood contributes to the problem. These problems were not created by those who placed the objects in the displays; they are a flaw in the design.

CONCLUSION:

We were attracted to the library due to its unique hexagonal shape and non-library elements within it. After doing some research about the room, we found it was originally planned to be a lounge. We believe that due to some connotations about the word lounge the space was renamed as the Alumni Library. We suspect that this contributes to the reasoning of why the space does not perform well as a library. Consequently, we decided to study the library according to its uses and intended purposes.

The original hypothesis has undergone several changes. We went from a very general intestable idea about the space to a highly narrow theory that was testable but did not involve a higher level of exploration. Now we are dealing with a question that encompasses more dimensions including both quantitative and qualitative analysis of the library. Our final hypothesis was that the lighting conditions, both electrical and day-lighting, are inappropriate for the activities typically performed in the library .

Our data and interpretations of the data show that the library is in fact adequately illuminated on typical sunny or cloudy days, but not on overcast days (see Appendix D). Although the library lights are kept on “house full” at nearly all times, the library is still not adequately lit when it is overcast, which could present a problem in that any reading tasks attempted in the library on such days would be difficult. The magnitude of this problem is fairly small, since the library is rarely used for reading activities. Also, even though the illumination in the library is proven to be sufficient, we experienced some visual discomfort there. This can be attributed to other factors such as light contrast and glare. Due to lack of accent lighting and uncomfortable amounts of contrast and veiling reflections, the memorabilia placed inside the cases are difficult to examine. It is possible that this is due to the fact that the designers of the display cases could not anticipate how the cases would be used.

Although the lighting conditions within the space are less than adequate under this intense scrutiny, compared to other buildings, the problems are minimal. Users seem to enjoy the space; no complaints were brought to our attention, even when we specifically asked if they had noticed any uncomfortable lighting problems. Even though there are minor errors in the lighting conditions, the alumni of Ball State should feel proud to have such a place to gather together.

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APPENDIX A: *INITIAL TEAM MEMBER IMPRESSIONS*

"My initial reaction to the building was pleasant. I enjoyed the layout and appreciated many of the little technological extras that enhanced the building. It was impossible for me to appreciate the live palm trees because, according to Matt Stevenson, they will push against the ceiling in twenty-five years. I feel it is a misuse of money and energy to light the trees so they grow. I was instantly drawn to the library because I enjoy spending time in libraries since my childhood. Out of all the rooms we toured, I felt the most comfortable there and desired to study it more than any other area."

-Naomi Tormoehlen

"When I entered the library, I thought the room looked like an informal gathering place. The couches and chairs were like traditional lounge furniture. The fireplace, big-screen TV and the pantry added to the relaxed atmosphere. I felt that the room wasn't lit well enough to make reading or related tasks comfortable for any length of time. Besides, there weren't any books or magazines to read. The light levels were fine for relaxation, but would have been uncomfortable if I had found any books or magazines to read."

-Jennifer Eastus

"Our study space, the library, with its large furniture and memorabilia displayed, has a very collegiate feel to it. It's almost as if there should be the smell of old leather and fight songs playing softly in the background. The room has a very comfortable atmosphere, but there seems to be a discrepancy in the lighting. The shelves are too dim to see in great detail the items on display. Also, the overall lighting seems to be inadequate for many of the activities that could be done there. Light necessary for reading, writing, and one-on-one meetings is simply not present. It will be interesting to find out the actual use and user impressions of the space."

-Clark Stranahan

"My initial response to the library was that it felt gloomy and uncomfortable. Right away I noticed a high level of indirect glare coming through the window and reflecting off one of the tables in the room. Also, someone had displayed some architectural renderings on a stand that were very hard to see at any distance because of the lighting. The perimeter of the hexagonal room was done with display cabinets, but the lights were not illuminating the items placed within. Overall, I really wouldn't want to read or do any 'library-associated' tasks in the room."

-Jason Foster

APPENDIX B: *VISITING SCHOLAR MEETINGS*

Jeff Sailer:

As an introductory presentation, it was great to see this class could ultimately be of great value to the students. Jeff's presentation on the effects of temperature changes on cold-blooded animals, especially reptiles, was not only educational but also entertaining. It is not often that students get a chance to converse with a former student who could share how this particular class influenced his goals in his own profession.

Alison Kwok:

During our group meeting on September tenth with Alison Kwok, we were in the very early stages of our group project and were still working on a hypothesis. She spoke about her experiences with a similar project for Vital Signs that she worked on in New York. She suggested we start by sitting in the Alumni Center and observing the lighting conditions and then developing some opinions that could lead to a hypothesis. She then talked about PhotoShop and other techniques to help prove or disprove our ideas. She asked us to each determine what we were good at and then breakup the tasks that we would each perform.

Bruce Haglund:

Mr. Haglund gave a presentation in which he showed the case studies his students had published on the Internet. He pointed out the fortes of each group's reports, like the real-time video tour and the computer-generated aerial views. When our group met with him in private, he listened to our critiques of the room and our plan on approaching our research. He suggested we not think of the room specifically as a library, but consider merely calling it the library while we studied the light levels as appropriate for the type of activities performed there. Other than that, the conversation was mostly social.

Joel Loveland:

Mr. Loveland asked questions that furthered our understanding of our experiment. He asked us to consider if the lighting brought order to the space; why the university would pay thousands of dollars for wooden louvers that do not work properly and if they were designed to be a light source for the room; if the center lighting fixture was suited for the room; and why the room was designed the way it was, with the television on the left. He suggested we enhance our study by spending time in the space, and concentrating on the two aspects of adequacy: subjective and objective. Unfortunately, our team could not meet with him as a group, so this information was combined from several group members.

Marc Schiler:

Mr. Schiler encouraged us by agreeing with our hypothesis; he also thought the lighting was inappropriate in the library. He suggested we delete insufficient from our hypothesis because inappropriate includes insufficent. We discussed architectural lighting errors. He felt we were working on too many aspects of the library and suggested we delete the television section of our methodology. This, he said, would enable us do concentrate and perform a few tasks well.

APPENDIX C: *IES ILLUMINANCE STANDARDS AND OCCUPANCY VOLTAGE LEVELS*

Illuminance Categories and Illuminance Values for Generic Types of Activities In Interiors

General Lighting Throughout Spaces	Range of Illuminance (in footcandles)
Simple orientation for short temporary visits	5-7.5-10
Working spaces where visual tasks are only occasionally performed	10-15-20
Illuminance on Task	
Performance of visual tasks of high contrast or large size	20-30-50
Performance of visual tasks of medium contrast or small size	50-75-100
Performance of visual tasks of low contrast or very small size	100-150-200

Voltage falloff levels for occupancy metering device

Time after activation	Voltage
0:15 sec	1.5V
0:30 sec	1.5V
0:45 sec	1.37V
1:00 min	1.30V
1:15 min	1.22V
1:30 min	1.13V
1:45 min	1.06V
2:00 min	1.00V
2:15 min	0.94V
2:30 min	0.87V
2:45 min	0.82V
3:00 min	0.77V

Fig. 22 *the fireplace in the library*

APPENDIX D: *RECORDED ILLUMINANCE VALUES*

Illuminance values for various areas of the library (in footcandles)

Area	11:45 a.m.	4:00 p.m.	Oct. 27, 1:55 p.m.
Southwest work table	60	120	14
In front of Signature window	120	160	48
Northwest work table	80	120	16
Northwest End table	60	30	15
Coffee table At fireplace	30	10	15
End table at Fireplace	15	10	17
In doorway Of the library	15	10	21
End table near entrance	15	10	12
Coffee table Near TV	20	15	15
End table near South door	40	40	15

Fig. 23 *window on south side*