Capital Market – Lighting Design

The capital market classroom is located on the first floor of the building. Capacity in the room is for 33 people including a professor. The classroom is set up with desks surrounding the room in a horseshoe, along with four groups of desks in the center of the room. These desks are set up with the unique considerations of the classroom in mind. This classroom is supposed to capture the atmosphere of a business environment, and supplement a students education of business studies. The four groups of desks in the center of the room hold three monitors a piece and provide the unique learning environment for the business students at George Washington.

Picture CM.1

Along with the special workstations and the LED stock tickers in the room, the next defining characteristic of the room is the east-facing wall. The wall is designed as a window wall, allowing substantial amounts of daylight to enter the space. A design such as this has its positive and negative implications. If designed properly, the daylight that enters the space can provide substantial cost savings, yet if the system is designed poorly, the HVAC loads and the direct sun light will cause a very inefficient and uncomfortable environment for anyone in the space.

As with the auditorium, the design of this classroom needs to be able to accommodate several different situations. The classroom needs to provide lighting on the task plane for reading and writing tasks, while also providing an environment that will support a lecture or presentation situation.

Picture CM.2

Once again the finishes in this room are very important. Next to the auditorium, this classroom is the second most likely to be utilized by not only the university, but also by people outside of the university. Accenting the room in the appropriate way is important in not only creating the proper atmosphere, but in creating a space that compliments higher learning.

Design Considerations

The biggest consideration in the design of this space was to utilize as much day light as possible. Not only is it important to use as much of the daylight as possible, but also to minimize the amount of direct light entering the space. Comfort, of course, is another important aspect in the design of the space. Improper utilization of daylight will cause the space to become uncomfortable, just as improper design and glare sources can cause discomfort to the people using the space. Having computers in the space, adds to the importance of proper consideration of glare and of veiling reflections. Lighting control will also play an important part in the design of the space, as it must be adaptable to the different types of uses.

Design Criteria

All design criteria are based upon the standards set forth in the IESNA Lighting Handbook, and the following criterion was taken from it.

Integrating daylight into the space to create a system that would produce cost savings was the primary goal in this design. Adding a light shelf to the space will help to use some of the light in the space. Utilizing solar-e glass to minimize some of the heating gains will also help in creating acceptable day light design.

Glare is an significant issue in this space, especially with the use of VDT's as an important part of the use of the room. Placement of fixtures, and the use of direct light to supplement louvered fixtures will help in the elimination of glare. With the east wall being a glass structure, glare for people sitting near the window will be hard to eliminate. Day light penetration is hard to eliminate in the morning with an east facing façade, and blinds will have to be used at the discretion of the occupants to eliminate this direct glare.

With so many visual tasks: writing, reading, VDT use, etc. in the space, contrast ratios will be very important. Distribution of light across the different work planes will have to be designed carefully to eliminate over contrast. Maintaining proper ratios according to IESNA standards will be important in creating a comfortable environment for the user.

Proper distribution across the work plane is also very important, as was indirectly stated in the previous paragraph. It will be important to supply the proper fc values on the work plane while also giving a distribution that lacks severe disparities. Distribution across the vertical work plane in the front of the room will also be very important.

Selection of lamps containing good CRI and CCT lamps is important to the space as well. Improper selection can cause the light to clash with the finish colors and help to create a space that is very visually uninviting.

Design Standards –

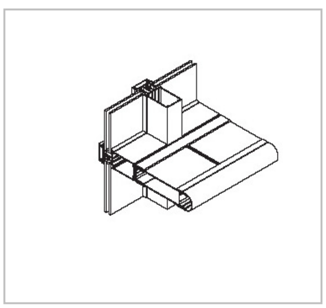
Horizontal Illumination
Reading / writing tasks – 40 to 50 fc

Vertical Illumination
Presentation / lecture – 50 fc

Power Density requirements
1.4 w/ft2 for presentation space **(Ashrae Standard 90.1 standards)**

Light Shelf Design –

To help bring the daylight into the space, a light shelf was added to the façade to help direct light with in. The exterior wall was already comprised of steal and glass, a horizontal mullein was simply added and the shelf was placed at that point. The shelf runs the length of the wall, and extends past the edge of the window slightly to maximize the light that can be direct in and minimize unnecessary daylight penetration. It is composed of simple aluminum steel, and the shelf is manufactured by Alco Building and construction systems.



There were structural concerns with the addition of a light shelf to the space. However, the addition of this particular shelf calls for the addition of a very small load. With a column spacing of 20', and sufficient steel bracing from the window frame to prevent sagging, the structural implications of adding a shelf are very insignificant. This load on a large steel beam easily supporting the building loads is inconsequential.

System Designs –

With the main criteria for this being the implementation of daylight, one of the biggest factors that correspond with the design will be any cost savings that the system can produce. The system was therefore analyzed not just with the changes to the façade and the addition of the light shelf, but four different luminaire systems were tested with in the space to examine how they would affect the design.

The biggest system variance was the type of luminaire that was placed in the room. Two separate luminaries were used in my study of the space, a fixture that is purely indirect lighting and a fixture that is a mixture of direct and indirect light. Each system has its advantages, not necessarily because of its integration in the space, but because of the characteristic of the system.

An indirect system in the space creates a duller atmosphere by eliminating many of the shadows created by direct light. Provided the luminaries are spaced properly on the ceiling, indirect features can eliminate fixture glare. Also, with dimming implications

placed in the room, fixtures can be shut off, as opposed to having them remain at a dimmed level. This may seem insignificant, but the human eye can perceive changes even if the fixture is switched on and off. When the ballast dims to it's lowest output, the energy use of energy becomes very inefficient. By shutting the fixture off instead of dimming to its lowest point, substantial savings can be made.

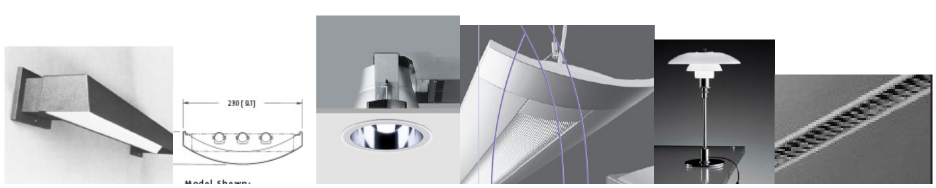
Direct and indirect systems make a more interesting environment. The direct light on the surfaces helps to create shadows, hopefully not unwanted shadows, which add some dynamic to the space. Also with the addition of the direct light to the space, it becomes easier to provide the proper lighting levels on the task plane. The louvered baffles on the fixtures will help to cut down on the glare that is more prevalent with the direct fixtures.

The other variable in this system was the number of rows of luminaries in the space. A two-row situation and a three-row situation were examined for the direct and the direct/indirect case. Eliminating one of the rows doesn't necessarily increase savings because you need to increase the number of lamps in the luminaire to achieve your design values. However, when considering the number of rows to dim with the integration of the daylight, it is important to understand the two ways in which the system could act.

Fixture Schedule –

Fixture cut sheets can be found in (**appendix L**), and the lamp and ballast data that was used with each of the fixtures can be found directly after it.

Label	Description	Lamps	Manufacturer	Voltage	Wattage	Ballast
A3	Wall mounted wall wash, countinuous mounting for even wash	(1) T8 - T8-A	Alkco	277	25W	Electronic
A4	3" wide continuous run fixture, louvered downlight	(1) T8 - T8-B	Se'lux	277	32W	Electronic
A5	Continuous run, pendant fixture, all indirect lighting	(1) T5ho - T5ho-A	Metalumen	277	49W	Dimming
A5a	Continuous run, pendant fixture, all indirect lighting	(3) T8 - T8-A	Metalumen	277	75W	Dimming
A6	Pendant fixture with direct and indirect aspects, louvered down light	(1) T5ho - T5ho-A	Axis	277	49W	Dimming
A6a	Pendant fixture with direct and indirect aspects, louvered down light	(2) T8 - T8-B	Axis	277	64W	Dimming
B2	8.5" circular recessed downlight, horizontal mounted lamp	(1) Triple tube - TTB	Erco	277	32W	Electronic



Lamp Data

Label	Type	CRI	CCT	W	Initial Lumen	Mean Lumen	Manufactuer
T8-A	T8	80	3500	25	2250	2050	Philips
T8-B	T8	80	3500	32	2950	2800	Philips
TT-B	TT	80	3500	35	2400	-	Philips
T5ho-A	T5Ho	80	3500	49	4900	4606	GE

Ballast Data

Label	W	Lamp	Dimming	BF	Manuf
BL-1	54	t5ho	yes	1	Lutron
BL-4	25	t8	no	1	Advanced
BL-3	32	T8	yes	1*	Lutron
Btt-2	35	TT	yes	1*	Lutron

* Exact ballast data was not given so one was used.

Light Loss Factor

There was an assumed room cleaning period of 12 months and the room was kept under the clean category. The calculated percent of expected dirt depreciation was 12%.

RC = (2.5 * 12 * 222.5) / 2708.1 = 2.5

Label	Maintenance Category	LLD	RSDD	LDD	BF	LLF
A3	V	0.80	0.95	0.88	1.00	0.67
A4	IV	0.80	0.98	0.39	1.00	0.70
A5	II	0.80	0.94	0.80	1.00	0.71
A5a	II	0.80	0.94	0.80	1.00	0.71
A6	VI	0.80	0.80	0.95	1.00	0.61
A6a	VI	0.80	0.80	0.95	1.00	0.61
B2	IV	0.80	0.98	0.89	1.00	0.70

Power Density

Label	Wattage	Quantity	Total Watage
A1	49	40	1960
A2	25	20	500
A3	25	6	150
B1	45	21	945
C1	50	2	100
		Total =	3655

According to the ASHRAE standards, the w/ft^2 can not exceed 1.4 for a lecture hall.

3655 W / 2709 ft^2 = 1.35 W/ft^2

Lutron Control Information

The same implications of the design of the Auditorium carry over into the design of the capital market classroom when controls are considered in the design. The same degree of variability is needed, and in this case a slightly smaller degree is needed. The same Grafik Eye system used in the Auditorium was used in this system. Once again the on and off switches were placed by the door, with a control panel placed at a position for easiest access.

Floor Plan

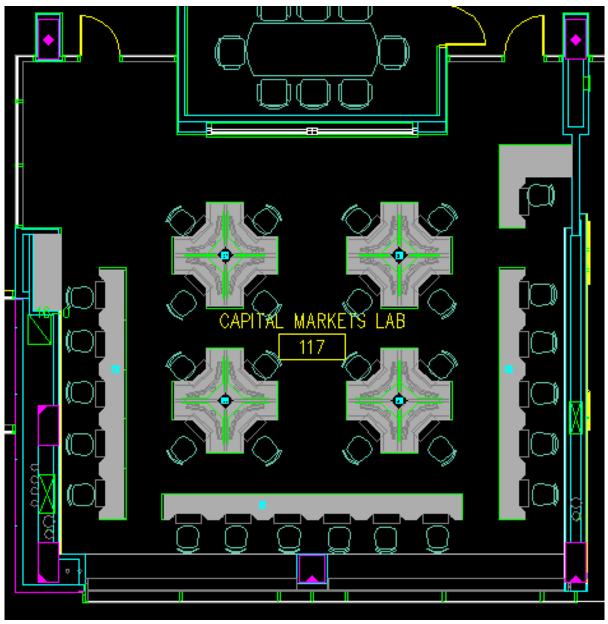


Figure CM.1

Calculation Data –

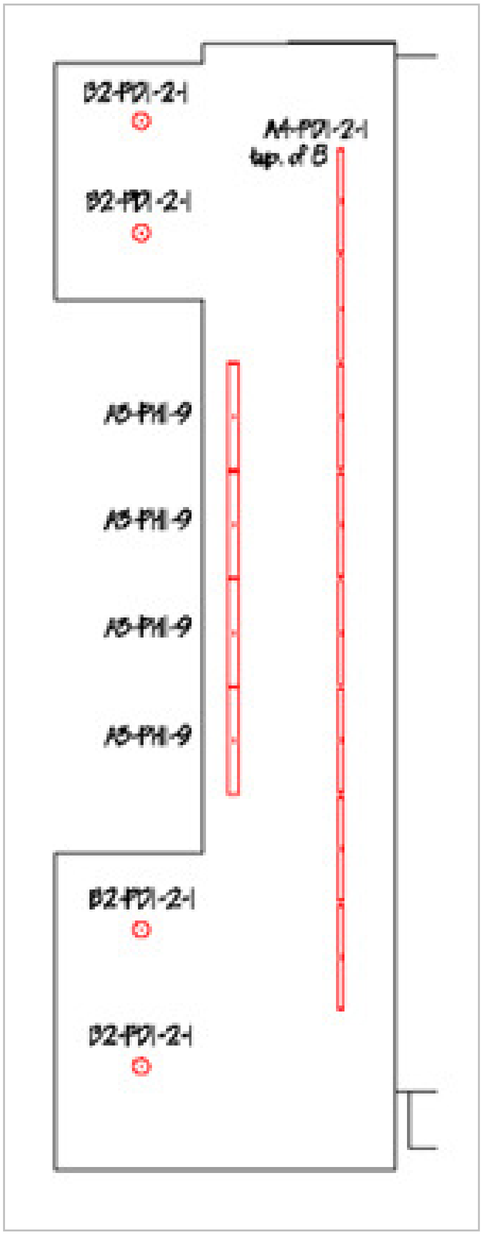


Figure CM.2

The design for the front portion of the classroom remains constant through the four individual studies that were performed within the classroom. Lights were provided along the board, and they are switched at a point next to the boards to enable convenience in turning them on and off. The main portion of the front of the room is lit by a 3" wide trough system that runs the length of the room. This is designed to provide adequate light on and around the presenter. These lights are tied into the same circuit and zone as the four recessed lights that light the entrances and exits of the room.

The room is switched in the same way as the auditorium is. There is a main dimming panel located at the front of the room for each access for the presenter/professor in the classroom, while a switch is located at either entrance for control when entering and exiting the space.

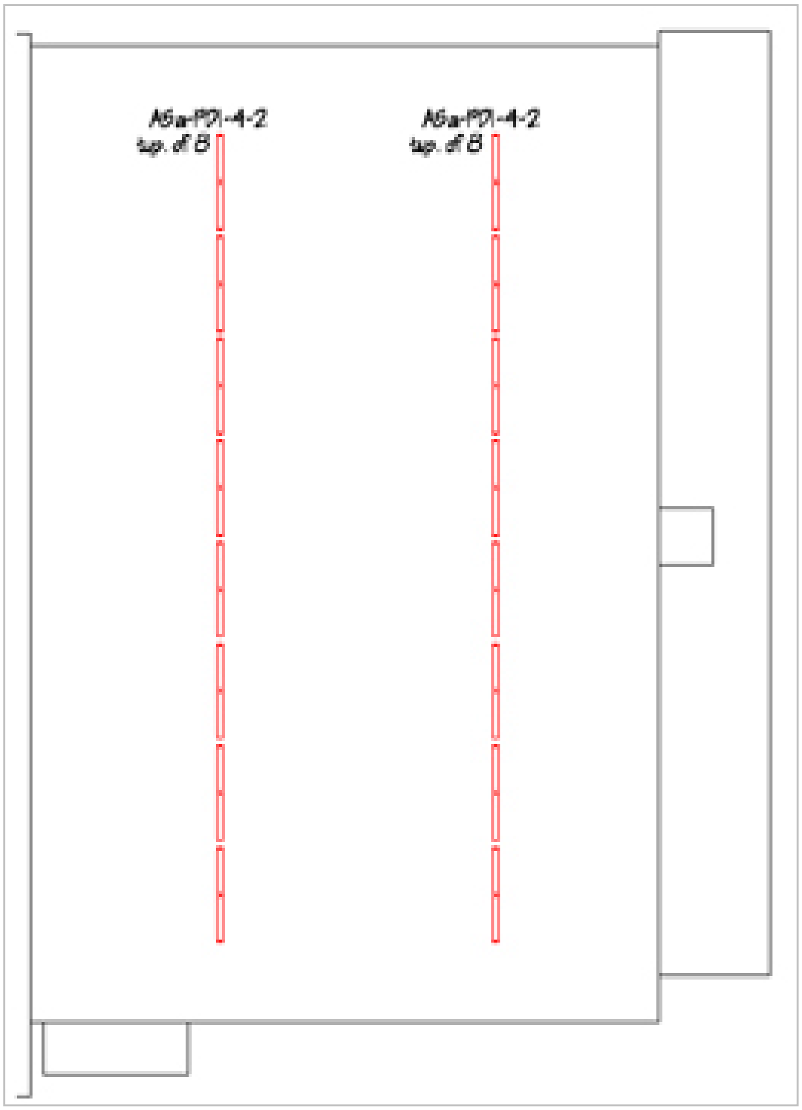
The following figures contain the luminaire layout for the auditorium. Each luminaire is labeled in the similar manner

X1 – PXX – X – X

The first number represents the fixture's representation in the luminaire plan. The second number is the panel on which the circuit can be found, the third number is the branch circuit on the panel, and finally, the final number is in correspondence to the dimming zone of the room when dimming is applicable.

Information from this previous portion of the room will not be represented with any of the individual design layouts. Each of the four designs is presented one after another in the following section.

2 Rows Indirect

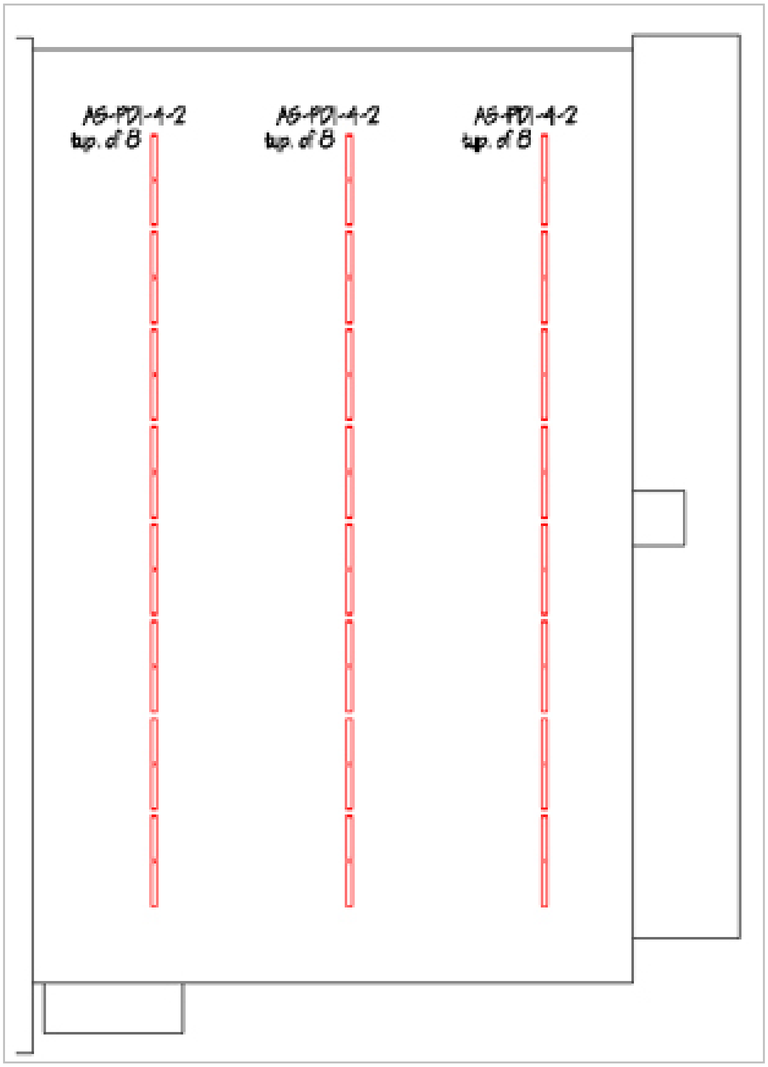


The two rows of Metalumen indirect fixtures are set up in the room as shown to the left in Figure CM.3. Both rows of luminaries are switched together and dimmed together. Once the critical point of the room is determined, a photosensor on the ceiling will be used to control the % output used by the luminaries in a dimming situation.

Figure Cm.4

Rendering CM.1

3 Rows Indirect

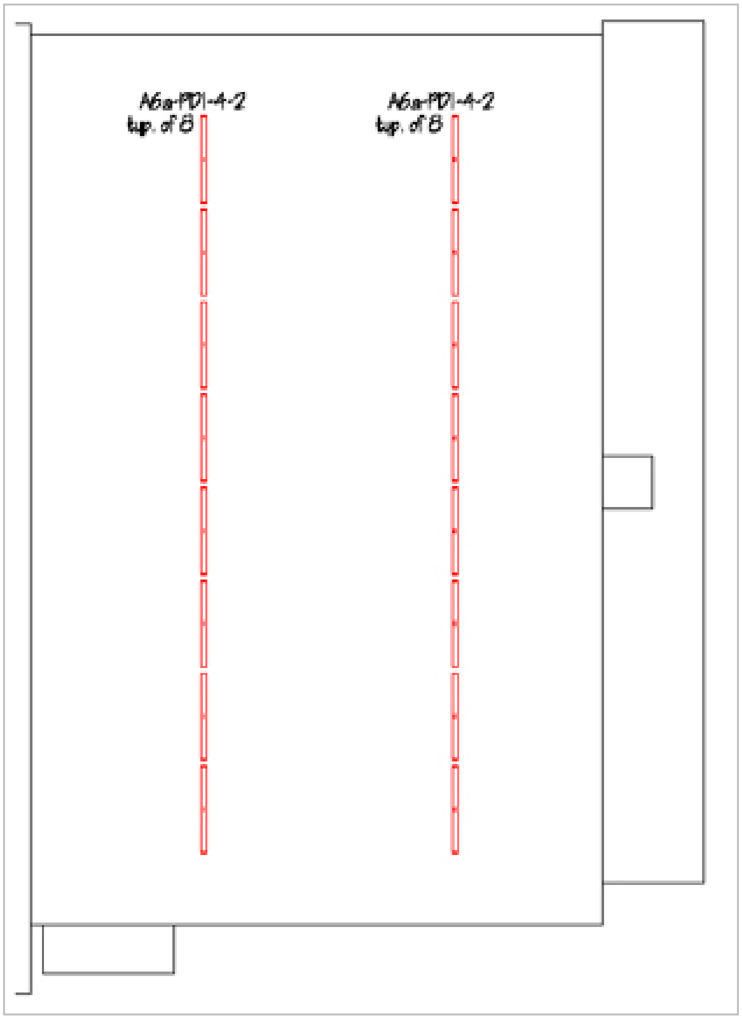


The set up to the left in figure CM.5 is the lighting layout for 3 rows of the indirect system. This set up uses the same luminaire as in the previous design but in this situation the luminaries have a different number of lamps. This system integrates with the day light in a different way. The row closest to the left side of the page will not be switched on and off; instead it will always be left on because of its distance from the windows. The remaining two rows will be dimmed based upon the critical point detected by the photosensor.

Figure CM.5

Rendering CM.2

2 Rows Direct/Indirect

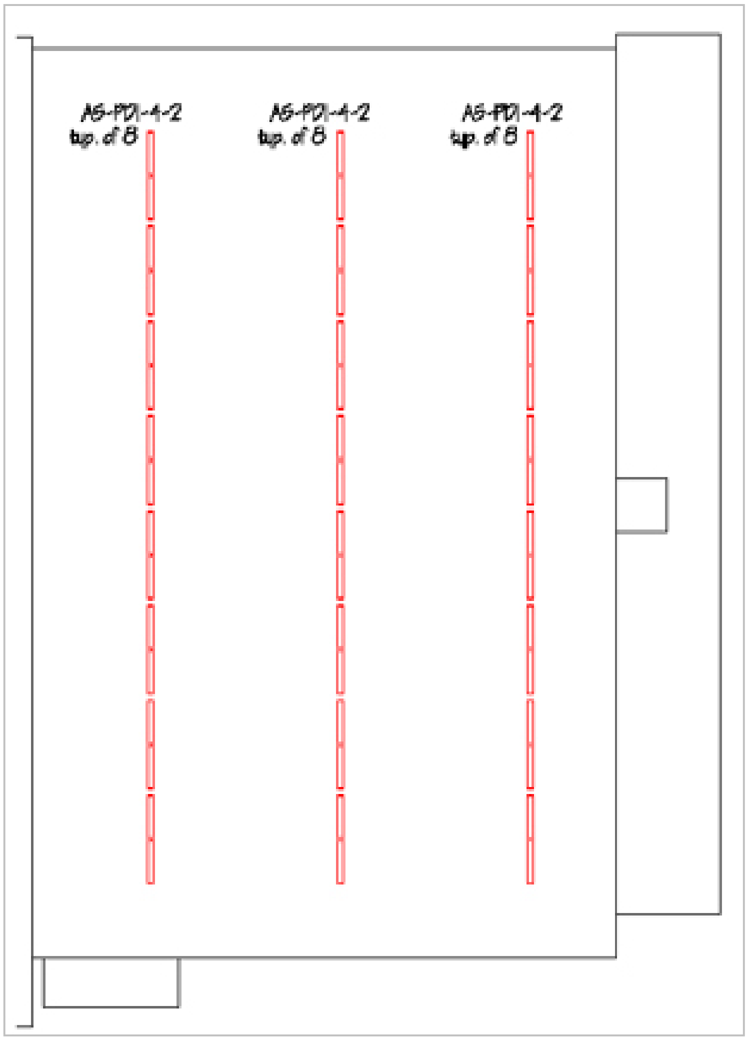


The third design once again involves the use of two rows; however, the indirect fixture was replaced with a direct/indirect fixture. A photosensor will be placed on the ceiling, and will monitor a critical point. The output of the lighting system will be adjusted according to this point.

Figure CM.6

Rendering CM.3

3 Rows Direct/Indirect



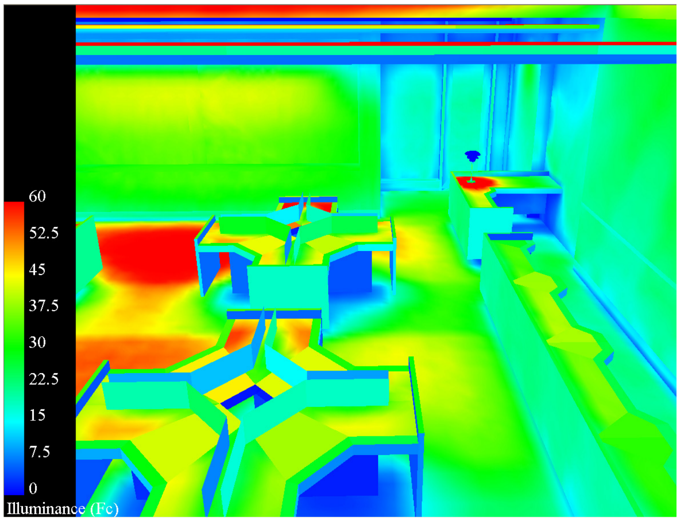
This design is a modification of the previous design. Once again, the direct/indirect fixture was used in the space, but a third row was added to the space. Switching will be similar to the second design. The row furthest to the left will remain on or be turned off, while the other two rows will be dimmed according to the critical point in the room. The value on the critical point will be determined by a photosensor on the ceiling.

Figure CM.7

Rendering CM.4

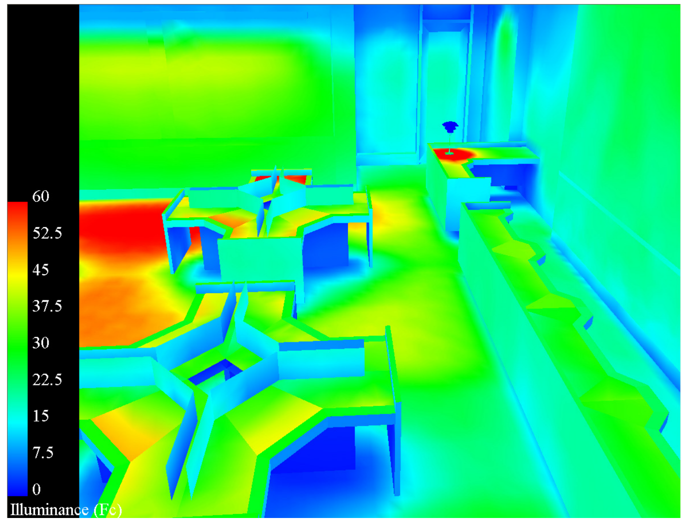
Lighting Level Comparisons

Pseudo Rendering CM.1



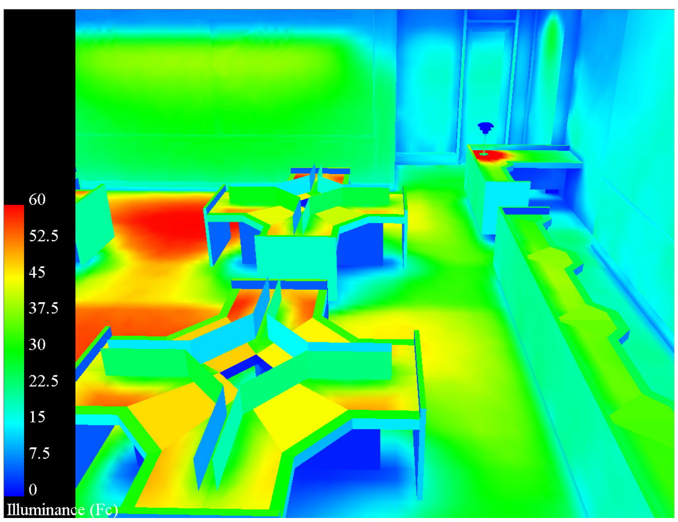
2 rows Indirect Fixture

Pseudo Rendering CM.2



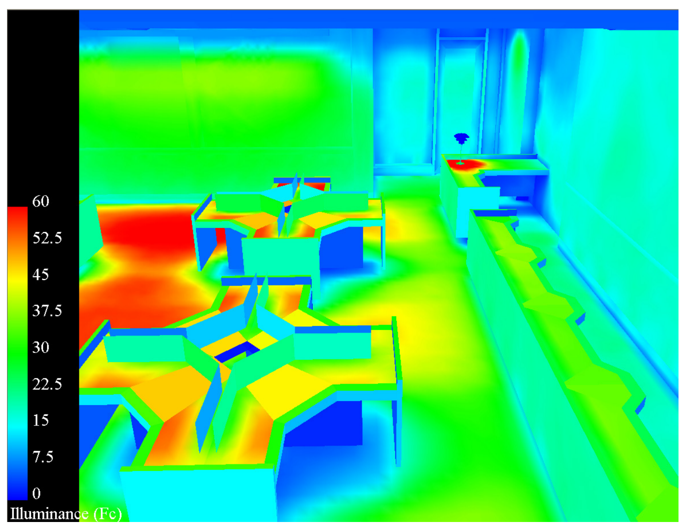
3 rows Indirect Fixture

Pseudo Rendering CM.3



2 rows Direct/Indirect Fixture

Pseudo Rendering CM.4



3 rows Direct/Indirect Fixture

The systems perform similarly when the fixtures remain the same, but the values do not tend to stay the same when changing from direct/indirect to indirect. The indirect fixtures have a lower fc value on the task, most likely due to the fact that that the light in the space must be reflected off of the ceiling first. All the fixture layouts do a very good job of spreading an even distribution across the task plane. The other inconsistency in the space is the lighting level on the desk on the right side of the frame. The desk only has an fc level of 35fc to 40 fc. This level is acceptable, and the levels will most likely often be greater due to the sunlight entering the space during the day time, but getting more light onto the edges of the room.

Daylight Analysis

A simple day light analysis was done to determine what type of affect dimming a portion of the fixtures in the classroom would have. Analysis was done on the 3 rows of direct/indirect fixtures as these are the ones I would choose to use within the space.

Energy Savings

	No Controls		All Dim		Selective Dim	
	KWh	Cost	KWh	Cost	KWh	Cost
January	507.8	48.76	362.3	34.79	375.6	36.07
February 1-21	327.6	31.46	233.0	22.37	242.4	23.27
February 22-28	145.6	13.98	87.0	8.36	102.1	9.80
March	564.2	54.17	340.4	32.69	397.1	38.13
April 1-21	382.2	36.70	226.1	21.71	266.3	25.57
April 22-30	163.8	15.73	106.5	10.22	110.5	10.61
May	564.2	54.17	368.5	35.38	381.0	36.59
June	546.0	45.50	344.1	28.67	364.9	30.40
July	564.2	47.01	352.4	29.36	376.0	31.33
August 1-21	382.2	31.85	237.7	19.81	254.4	21.20
August 22-31	182.0	15.17	104.1	8.68	124.4	10.36
September	546.0	45.50	309.9	25.82	373.1	31.09
October 1-21	382.2	31.85	213.5	17.79	259.9	21.66
October 22-31	163.8	13.65	111.3	9.27	115.8	9.65
November	491.4	47.18	346.1	33.23	358.3	34.41
December	507.8	48.76	362.3	34.79	375.6	36.07
	Total Cost:	581.43		372.96		406.20
	Savings:			208.48		175.23

By dimming a single row, cost savings of over 100 dollars a year were made for this space alone. This examines the cost savings if there was one row that remained on ata ll times. After looking at the fc levels, dimming would seem to be a better solution with more possible cost savings.

Conclusion

The room itself does not produce large amounts of cost savings; however, if this type of switching would be spread over the entire façade, the savings would increase with the addition of each space. Another consideration is the type of building this is, and the type of use that each space will be receiving. In an environment where the use of powerpoint presentations will be predominant, there is little need for such switching as the lights will seldom be on long enough to operate in any type of efficient manner.