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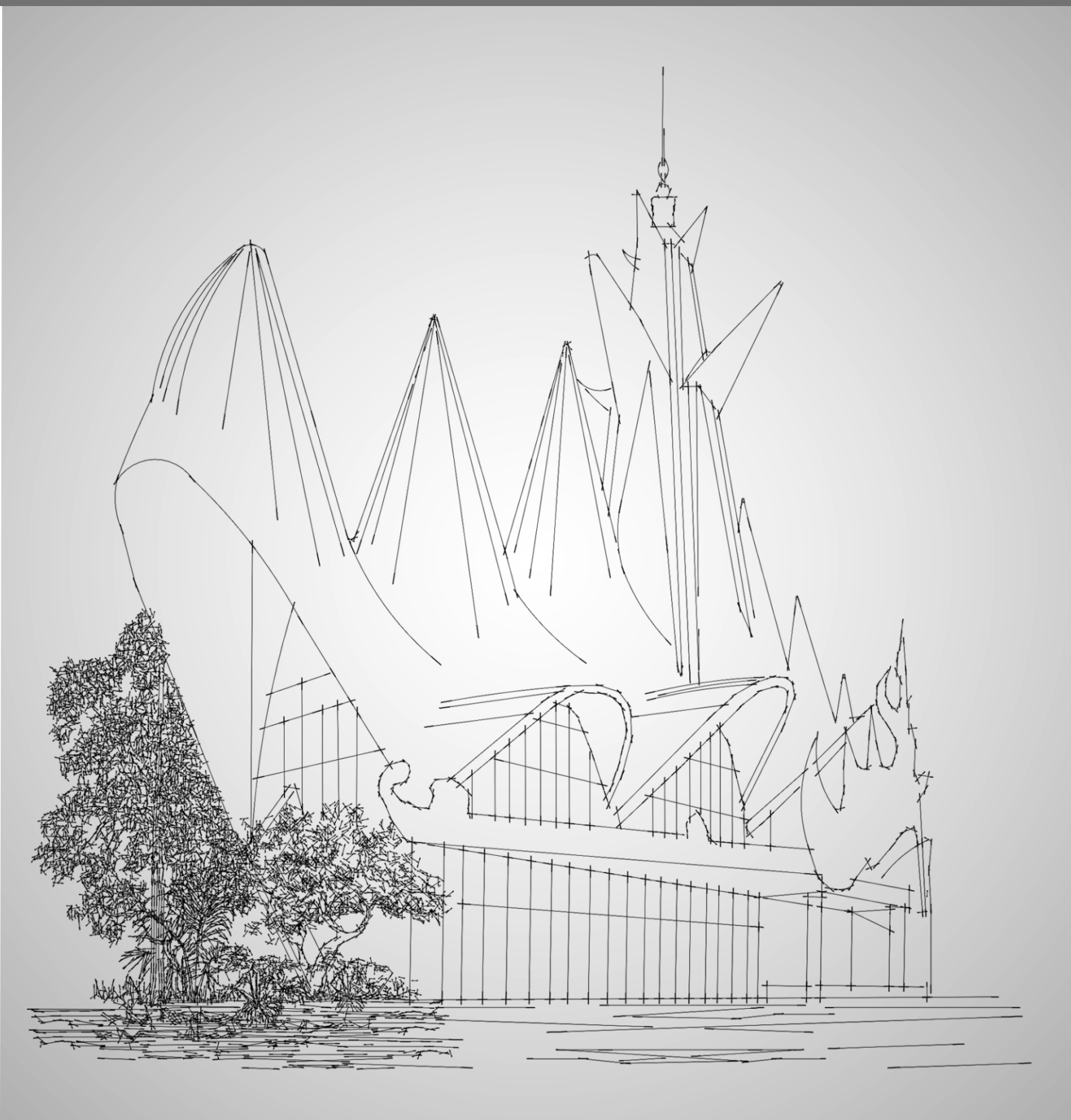
JURNAL ARSITEKTUR UNIVERSITAS BANDAR LAMPUNG



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Salam Arsitektur!

# The Improvement of Architecture Studio Classroom with Daylighting

Diptya Anggita, ST., MT.[1]

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**Abstract**

Architecture studio classroom is the primary facility for an architecture major, where the most activity is drawing. It needs illumination extra compared other activities such as writing and reading. Most of students spend more time in studio classroom and used it more than seven hours per day. It means a good design of a studio classroom is very important to fullfill the need of architecture student, such as illumination level. Some researches shown that using daylight in classroom is a good solution for keeping the health, psychology, and productivity of the student. So, the implementation of daylight is very important to be considered. Moreover, another reason of using daylight is for saving the energy for electrical consumption.

This research strengthen about the importance of daylight in an architecture studio classroom against the activity of a student and to showed the daylight condition by taking a case study of Architecture Department, Faculty of Engineering, Pancasila University. There are several stages in this reasearh. First, is evaluating the daylight condition of architecture studio classroom. The evaluation contained observation, daylight calculation, and interview of architecture student. Second, is about the discussion based on the result of evaluation of daylight condition and theories of daylight. The last stage, is design concept that will become a solid foundation for the improvement of studio classroom.

**Keywords**: daylight, studio, classroom

## 1. Introduction

As international concern has become centered on natural resource consumption and carbon dioxide emissions, increased energy consumption around the globe has led to a quest for more sustainable practices (Taylor, 2002). The worldwide primary energy consumption of buildings is close to 19 million barrels of oil per day (Santamouris, 2001b). Using renewable natural light in a space reduces the need for electrical light, which is usually generated at the expense of non-renewable resource. Another factor is energy cost saving, which is closely associated with energy concervation, but is distinctly different. When sufficient daylight is available, which depends on the location and climate, a good daylight design allows artificial lighting to be lowered or turned off. That can reduce the energy cost for lighting (Andre & Schade, 2002).

Daylight has become increasingly important in building, in part it is recognised as related to improved morale and productivity of the people, which are working or living, in such buildings. No electrical lamp can match the variation of daylight. The human eye adapts easily to daylight and especially windows give the occupants a sense of contact with the outdoor (US Department of Energy, 2002). The information that our brain receives from the illuminated environment is an essential element in shaping our mood, reactions and physiological well being (Sze-Hui, 1999). So, psychological benefits are good reasons for using natural light. Daylight generally increases occupant satisfaction by providing a healthier and more pleasant environment. It seems like humans function better, emotionally and physically under natural light, it seems like our bodies were designed for natural light (Erik, Jutta, 2002).

By receiving the full spectrum light the human body get beneficial effect like producing more vitamin D, get a better calcium absoption, metabolishm, and hormone secretion. We get some vitamin D from the food, but up to 90% of the vitamin D in our body is bult up by the reaction that occurs when our skin get exposed to ultraviolet light, which is present in e.g sunlight. (Erik & Jutta, 2002). A study on daylight schools shows that students get more productive in daylighting schools, than in traditionally illuminated school. Student with optimal daylight in their classroom progressed 20% faster on math test and 26% faster on reading test in one year, compared to students in the least daylighted classrooms (Plymton at al, 200). Students tend to be more attentive and display lower levels of hyperactivity (Thayer, 200).

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Indonesia has tropical humid climate. One of the characteristic is to have solar radiation which is quite high >900 W/m² (Satwiko,2008). So, the use of daylight building is very possible in Indonesia.

## 2. Literature Review

Most daylighting systems are designed assuming that no direct solar radiation enters the building through the apertures. First, the direct solar component is not needed to provide adequate daylight factors (illuminance) in most climates during most of the day. Second, direct solar radiation brings unwanted heat gain—which if admitted into a building will greatly decrease the luminous efficacy of daylight. Third, direct solar radiation admittance greatly increases the potential for direct glare experiences.Thus, some form of shading should be used in conjunction with sidelighting. (The Green Studio Handbook, 2007).

Daylight can be handled quantitatively in two ways: by using luminous quantities (daylight level) and by using relative value (daylight factor). (Chan, 2008).

### 2.1 Daylight level (flux, illuminance)

By a set of outdoor conditions and calculating the resulting interior illumiances. There are standard of lighting: SNI (Standart Nasional Indonesia) 03-6197-2000 and American National Standard Guide for school lighting.

Tabel 1. SNI Lighting Standard and American Lighting Standard

| Area | | Lux |
|---|---|---|
| **SNI (Standart Nasional Indonesia) 03-6197-2000** | | |
| Lembaga Pendidikan | Classroom | 250 |
| | Library | 300 |
| | Laboratory | 500 |
| | Drawing room | 750 |
| **American National Standard Guide for school lighting.** | | |
| Task | Reading printed material | 300 |
| | Reading pencil material | 700 |
| | Drafting, benchwork | 1000 |
| | Up reading, chalkboards, sewing | 1000 |
| Classrooms | Art room | 700 |
| | Drafting room | 1000 |

Source: SNI 03-6197-2000 and Source: American National Standard

### 2.1 Daylight Factor (DF)

Daylight fator is a numerical ratio used to describe the relationship between indoor and outdoor daylight illuminances (typically under overcast sky conditions).

The daylight factor is defined as: [DF = (Ei/Eo) x 100%] where, Ei = illumination due to daylight at the point on the indoor's working plane; Eo = simultaneous outdoor illuminance on horizontal plane from an unobstructed hemisphere of overcast sky.

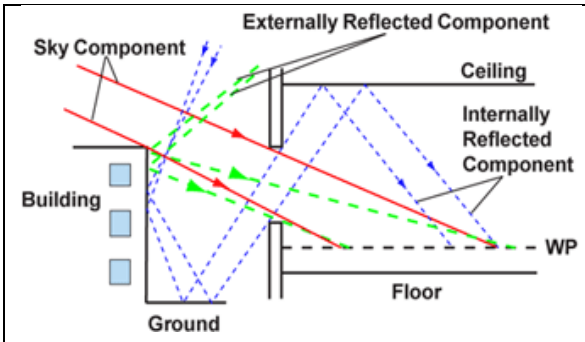



Figure 1. The Three Components of daylight
Source: http://www.blc.lsbu.ac.uk/webcreatif/BES/lighting-9/T9-5.html

Three components of daylight:

1) The Sky Component/SC, this is the light reaching the point directly from the sky;
2) The Externally Reflected Component/ERC, this is the light reaches the point after being reflected from surface outside the room such as buildings or roads;
3) The Internally Reflected Component/IRC, this is the amount of light that reaches the point after being reflected from other surfaces in the room.

The arithmetic sum of the these three components gives the daylight factor thus:

[DF = SC + ERC +IRC]

From a subjective perspective, the following user responses to daylight factors have been suggested:

a) With a DF of less than 2%, a room will seem gloomy. Electric lighting will be required for most of the daylight hours.
b) With a DF between 2% and 5%, a room will feel that it is daylit, although supplementary electric lighting may be needed.
c) With a DF greater than 5%, a room will feel vigorously daylit. Depending upon the task at hand, electric lighting may not be necessary during daylight hours.

Tabel 3. Suggested daylight factor criteria (under overcast skies)

| Space | Average DF | Min. DF |
|---|---|---|
| Commercial/ Institutional | | |
| Corridor | 2 | 0.6 |

| | | |
|---|---|---|
| General Office | 5 | 2 |
| Classroom | 5 | 2 |
| Library | 5 | 1.5 |
| Gymnasium | 5 | 3.5 |
| Residential | | |
| Dining Room/studio | 5 | 2.5 |
| Kitchen | 2 | 0.6 |
| Living Room | 1.5 | 0.5 |
| Bedroom | 1.0 | 0.3 |

Source: The Green Studio Handbook, 2007

Tabel 4. Typical recommended minimum daylight factors for rooms with side lighting only

| Building Type | Location | Daylight Factor % |
|---|---|---|
| Drawing Office | General | 2 |
| | Drawing Board | 6 |
| School & Colleges | Art Room | 4 |
| | Assembly & Teaching areas | 2 |

Source: Assisted Interior Design (AID) http://home.wlv.ac.uk/~in6840/index.htm

## 3. Method

There are several stages in this research. First, is about evaluation of daylight condition in studio classroom. This research was taking a case study of one of studio classroom in Architecture Department, Faculty of Engineering, Pancasila University. The evaluation contained observation of daylight studio classroom, daylight calculation with ectotect, and to enchance the information student interview conducted. The Interview contained the view from architecture student and lecturer about studying in architecture studio classroom using daylight with or without artificial light and studying in outdoor.

There are several points in the interview question, such as the best seat location, student focus, student product, the level of drawing detail, mood, and interaction between student.

Second, is about discussion by comparing between the result of evaluation and theories. The last stage is design concept that appropiate for improvement of studio classroom architecture as a conslution of this research.

Tabel 5. Criteria

| Criteria | A | B | C | D | E | F | G | H |
|---|---|---|---|---|---|---|---|---|
| Large Room (assuming the bigger room will be better to represent the other room because it has complex problem). | • | | | • | | • | | |
| The window is not obstructed by surounding or far from other building. | • | • | • | • | • | | | |
| Large Window | | | | | | • | | |

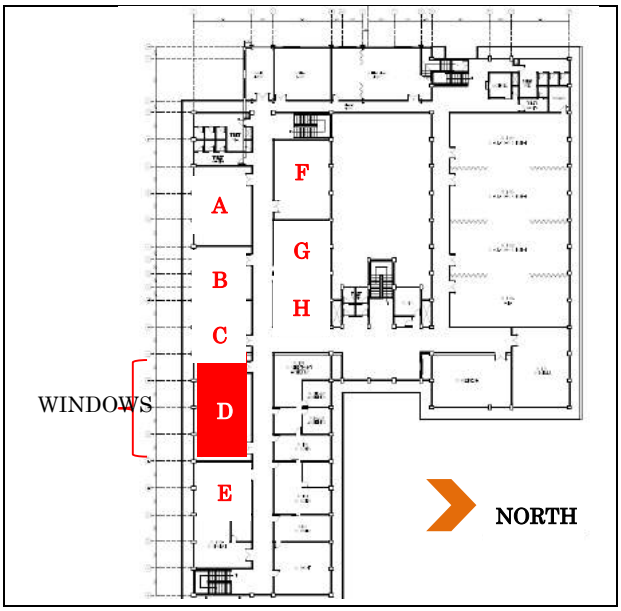



Figure 2. Layout of the room in the building. Studio classroom 'D' as a study case represent the other studio. The studio classroom located in the fourth floor which is the top floor of Engineering building.

## 4. Result and Discusstion

4.1. Observation of Studio Classroom

Daylighting is the complete process of designing buildings to utilize natural light to its fullest. It includes all of the following activities. (Mark, James, 2004):

a) Siting the building. The study case building, Engineering building has a building orientation towards the east, but the windows are in the northern and southtern part of a building for optimum solar exposure, except the additional building (additional building build in 2014). All classrooms have windows and diretly adjacent to the outside of building. It means that the early planning building had considered with no direct solar radiation enters the building.

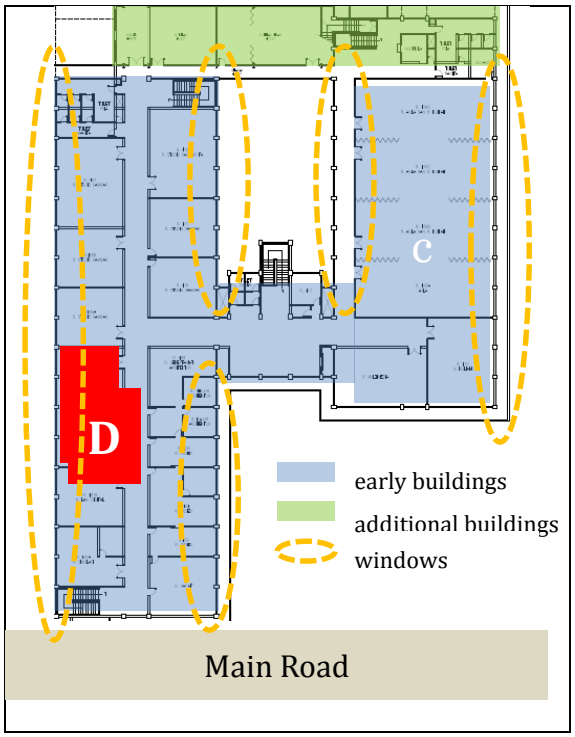
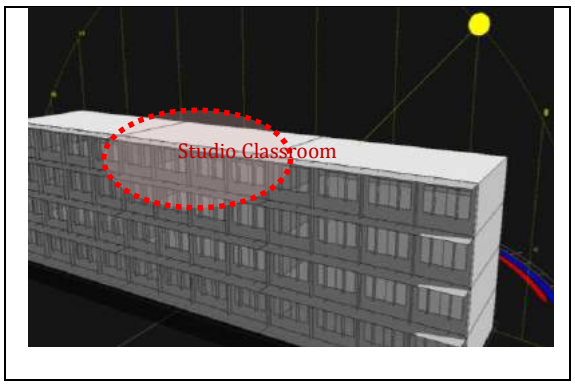



Figure 3. Layout of early building, additional building, and windows

b) Massing the building. The study case building, Engineering building has rectangular form with the widdest space toward north and south. The smallest space toward east and west. The observation and simulation of exterior building shading showed that most of the entire building envelope covered by shadows. It means that the early planning building had considered to reduce the heat and glare from direct sunlight, because Indonesia has a quite high of solar radiation.



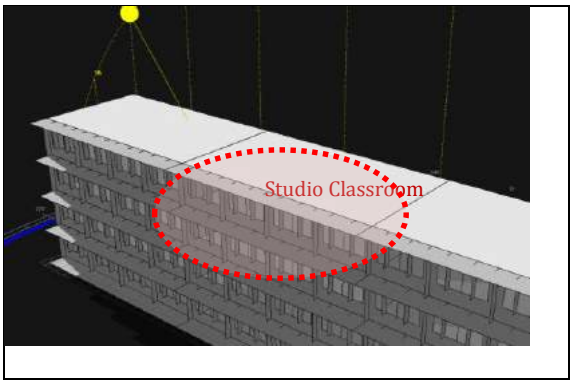




Figure 4. Sun Path and Exterior Sunshades (ecotect-3D) at 09.00 AM and 15.00 PM.

c) Choosing fenestration to permit the proper amount of light into the building, taking into account seasons, weather, and daily solar cycles. Based on The Green Studio Handbook (2007), the windows type of classroom studio architecture in Pancasila University is sidelighting and use windows film (80%). Sidelighting is a daylighting strategy that uses apertures located in the wall planes as the point of admission for ambient daylight. All Window system of the classroom studio deliver daylight onto a horizontal task plane generally from the side and utilize windows as the daylight aperture. Daylight only enters from the south direction of the studio classroom, because it is directly adjacent to the outside of the building. While the boundary to the north, east and west are rooms and corridors.

The observation showed that daylight of the classroom unable to work optimally, because the addition of window film in studio classroom make the room getting darker. The use of the film window in order to avoid the heat of the studio classroom and to reducing the electrical energy of the air conditioner. But these conditions made the students use artificial light to fulfill the need of light and also increase the electricity consumtion. So, the use of window film to reduce the electrical energy being improper.

Figure 5. The condition of the studio classroom architeture at 12.00 and 15.00 PM.

d) Adding appropriate operable shading devices. Base on observation, this building has overhang, columns, and grating on the building façade to produce the effect of shadows. So, the building can protected from direct sunlight.. Those shading divices are permanent. It means the interior building needs non-permanent shading devices to permit occupant control over daylighting admisstion. There are window shades at front of the studio. It is no-permanent and use to make the room darker for presentation with proyektor, but it always cover the window all day. It makes studio classroom darker.

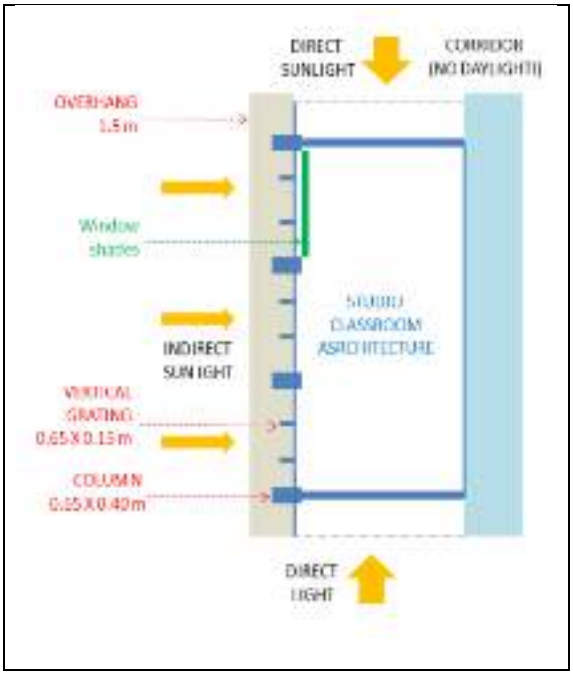



Figure 6. Studio Classroom

Figure 7. Window Shades

e) Designing electric lighting controls that permit full realization of the energy savings benefit of daylighting.

Based on obervation, the studio classroom always use the electrical light all day at 08.00AM until 17.00 PM. It showes that natural lighting not utilized.

**4.2. Daylight Calculate**

This research use ecotect simulation to simulate daylight level and daylight factor. Grid analysis for classroom is 08.00 m (high desk). There are several factor to be considered such as wall material, windows material, colomn, grating, overhang, climate, location coordinate, etc.

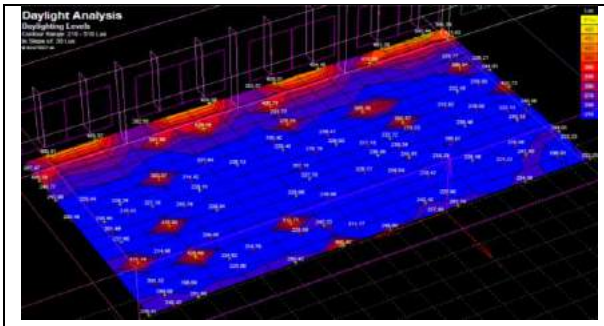



Figure 8. Daylight Level of studio classroom

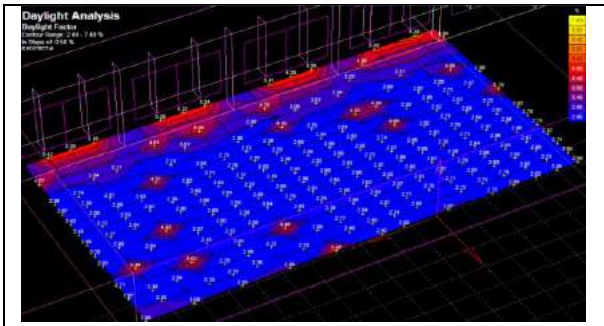



Figure 9. Daylight Factor of studio classroom

The result of daylight level simulation show that

the lowes illumination inside room is 192 Lux and the highest is 540 Lux, averange value is **258,56 lux**, most regions near windows having high illumination, and the illumination of the classroom is uneven. Based on SNI standard drawing room and art room need 750 lux and 700 lux based on American Nastional Standard. And the result of daylight factor level also same. The result shows that the lowest is 2.30% and the highest is 6.38%, average value is **3.04%**, most regions near windows having high value, and daylight factor enter the classroom is uneven. That explains why the student always use artificial light all day to fullfill the needs of light. So, studio classroom needs more daylighting to enter room and equalization of daylight room.

**4.3. Interview of Architecture Student**

The result of the interview showed that most of students prefer to study with addtion of artificial lighting, because the studio classroom will be dark if only use daylighting. Students runs more enthusiastic when drawing outside of studio classroom. The best seat location in studio classroom is near windows even using artificial light. It means that students need interaction from outside building. The concentration of student easily distracted and the interaction of the student would increase if the studio classroom were dark (without artificial light).

Table 2. Informants

| Informants | | Interview Date/Time |
|---|---|---|
| C. I | Architecture Student | September, 3, 2015/ 09.00-10.00 AM |
| A. F | Architecture Student | September, 3, 2015/ 09.00-10.00 AM |
| W. F | Architecture Student | September, 3, 2015/ 09.00-10.00 AM |
| L. A | Architecture Student | September, 5, 2015/ 09.00-10.00 AM |
| J. K. W | Architecture Student | September, 5, 2015/ 09.00-10.00 AM |
| A. M | Architecture Lecturer | September, 3, 2015/ 13.00-14.00 AM |
| A. B | Architecture Lecturer | September, 4, 2015/ 13.00-14.00 AM |

Source: Interview, 2015

**4.4. Desain Concept**

Based on the evaluation, the studio classroom need to increase the illumination value to fullfill the standard of drawing room and to equalization of daylighting. So, entire architecture studio classroom can get illumination value accordance with the standard. The conclusion can be achieved with the addition of some daylight innovations or removing something which is not needed. As a design concept, there are several improvement to increase daylighting condition of studio classroom:

a) Maintaining old windows and removing window films in order to increasing illumination value of the architecture studio classroom.
b) Adding light shelves. So, daylight can distributed deeper and equetable into the arhitecture studio classroom and the illumination value can increased. Light shelves will be located above eye level to reduce the potential of glare from the reflective upper shelf surface and the top surface of light shelves at least 0.6 m. And the other reason to instaled light shelves so high is safety because the light shelves extends into the studio classroom. So, if the shelves installed above the height of a tall people, they could walk under shelves.
c) Adding skylight to make use of a roof corridor. Architecture studio classroom location is on fourth floor. So, It is possible for daylight to entry from top of the room. A skylight placed in the corridor to avoid too much light that enters the studio classroom and may also be utilized as corridor lighting.
d) Adding new windows in order to let the daylight corridor into the studio classroom. Those new windows use small light shelves (blinds) for reflecting daylight corridor into the ceiling of the studio classroom.
e) Maintaining old windows in order let the daylight corridor into the studio classroom.
f) The ceiling distributes the daylight to the occupants. The ceiling will be higher in order to let daylight corridor into the classroom easly. The ceiling plays the same roles as the fixtures in electric lighting and will be highly reflective to conserve as musch light possible. The ceilling height will be at least 3m. Light shelves use a mirror or alumunium that is installed outside and inside a window, facing upward. The mirror will reflects incoming sunlight toward the ceiling. The ceiling then distributes the light into the working areas of the studio classroom.

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