Identification of Visual and Thermal Comfort in Classroom

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Identification of Visual and Thermal Comfort in Classroom

Debby Seftyarizki*, Abdul Hamid Hakim, Makmun Reza Razali

Universitas Bengkulu, Bengkulu, Indonesia

* debby.seftyarizki@unib.ac.id

Abstract. As a learning facility which has interaction inside it, a classroom should be comfort in term of visual and thermal. Visual comfort can be obtained by the presence of sunlight through opening. While thermal comfort is the air temperature that influenced by building material used. Room 21 (R.21) of Gedung Kuliah Bersama V (GB V) Universitas Bengkulu (UNIB) is a classroom that mostly used by Architecture Student for receiving lecture from morning until afternoon. To identify the visual and thermal comfort of R.21, computer simulations with Ecotect program was did to get the room lighting and temperature condition in level 60cm above the floor. The result shows that natural light in R.21 GB V UNIB is comfortable enough with 630 lux of average daylight levels. While the temperature in R.21 GB V UNIB is still not comfortable because the average mean radiant temperature is 26,6^{o}C. Visual comfort obtained along with high temperature because R.21 GB V UNIB is located at the corner of the building that have glass window in the east and north of the room. **Keywords**: Visual Comfort, Thermal Comfort, Classroom

1. Introduction

Energy efficiency already became a huge issue in architectural field. According to BPPT, most of energy used in a building is for lighting and air conditioning [1]. This energy is used to obtain the comfortable when doing indoor activity. One of the methods to pursue the efficiency of energy is by using natural resource. Utilize natural lighting and maintaining room temperature through building material also became one of the characteristics of green building according to Green Building Council Indonesia. But, one of the problem by using natural resource is create another question, 'is it comfortable enough?'.

Classroom is a face to face place for transferring knowledge. Since there's an interaction inside it, a classroom should be comfort in term of visual and thermal. Another activity inside a classroom is reading and writing from morning until afternoon. Therefore, the sufficient amount of lighting and appropriate condition of room temperature plays an important factor to obtain the comfortable inside the room. Natural lighting can be obtained by the presence of natural light, while one of the factors that influenced thermal of the room is air temperature. Natural lighting inside the room is mostly coming from the opening or window at the wall. But sometimes, utilization of natural light will also bring the heat along because transparent material can transfer bigger heat into the building. That's why building envelope material also plays a role to transfer the heat from outdoor to inside of the room [2].

The presence of natural lighting through opening can make an interaction between indoor and outdoor that improves the quality of the room. As an example, the renovation of Asian Development

Bank Headquarter building in Manila to bring in the natural light can increase employee productivity [3]. A good quality of the lighting inside the room makes the building user see clearly and comfortable. There're also several research about lighting of classroom, such as measurement of natural light intencity in elementary school with the data of room dimention, floor, ceiling, and wall color, room orentation, opening material and dimention, floor elevation, daylight condition, and date and time simulation using statisic software [4]. Another classroom lighting intencity analysis also used computer simulation to get the daylight factor of architecture leture room with room orientation, room dimension, opening material and dimention, and outdoor components as the variabels [5], and building performance of natural lighting, natural ventilation and room temperature using Ecotect simulation software [6]. Room dimention, building envelope material, and building orientation give an impact to the result of their study. Most of the result study showed that the lighting inside the room is under the standard. It happens because the window is only in one side, east or west opening only on spacious and deep room.

With several facts from studies mentioned above, visual and thermal comfort of classroom in Universitas Bengkulu (UNIB) is need to be identified. There's still no study about visual and thermal comfort of the classroom in Gedung Kuliah Bersama V UNIB. Identification did by seeing the distribution of room temperature and lighting occurred. Because there'll be inequality of room heat and light inside the room, for example, there'll be an area that received too much light or heat while others is received less light or heat. According to SNI 03-2396-2001, a good quality of natural lighting inside a room is light level minimum should be present not only in the area near the window but also on the whole of room, and there's shouldn't be a contras lighting between an area that received too much light or received less light because it can disturbing the vision [7]. According to SNI 03-6572-2001, thermal comfort can be obtain by distribute air temperature evenly. So, this study will try to look the light and temperature in detail on every corner of the room [8]. The final purpose of this study is to known the effectiveness of the classroom as a learning activity so that the learning facility can be more optimize.

2. Methodology

Identification of visual and thermal comfort of classroom in GB V UNIB did by computer software simulation Ecotect. Simulation did to known the room light and temperature condition. Simulation result will show the image that represents the room light and temperature distribution. Qualitative description did to explain the result of simulation. Room 21 (R.21) of Gedung Kuliah Bersama V (GB V) Universitas Bengkulu (UNIB) was chosen as the object study because this classroom is mostly used by Architecture Student for receiving lecture from morning until afternoon. R.21 is located at the corner of the building and faced 5 degrees to north-east. It makes R.21 has 8 windows faced to east and 4 windows faced to north. There's also glass door and small window at the west side of the room face to indoor corridor. R.21 has 8m in wide and 6m in length with wall brick, concrete floor and ceiling, and clear glass and aluminum frame for windows and doors. Simulation software has limitation in providing climate data, whereas no climate data for Bengkulu area. The nearest country that has complete climate data in Ecotect is Malaysia. Therefore, Malaysia climate data are being used is for this simulation along with Bengkulu coordinate. Thermal simulation time did on middle of April and September at 9am, 12pm, and 3pm. It's assumed as the class schedule for first-half academic year and second-half academic year. April is chosen as simulation time because this month is the representation of dry season. Meanwhile September is the representation of rainy season for simulation time. These simulation time considerations are based on SNI 03-6389-2000 about sun radiation data for building energy conservation [9]. Since there's no other building around GB V, obstacle and another external factor are being ignored.
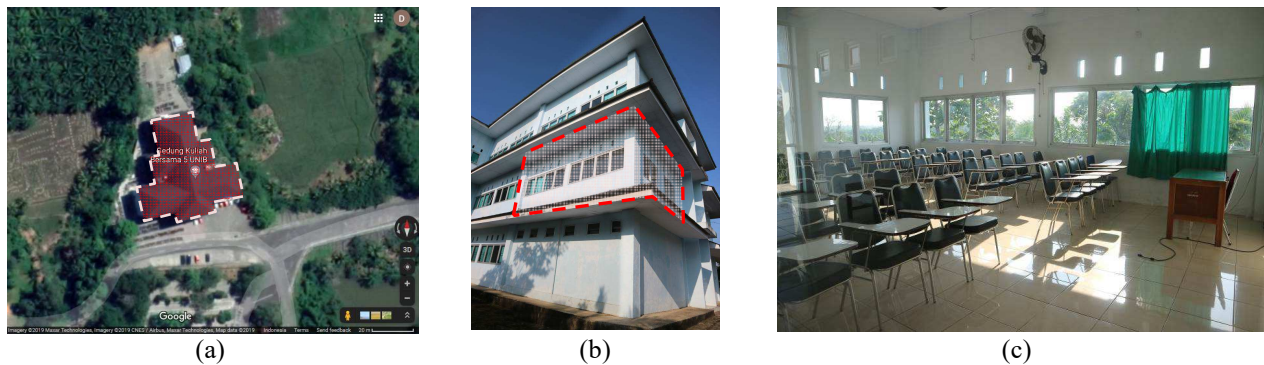
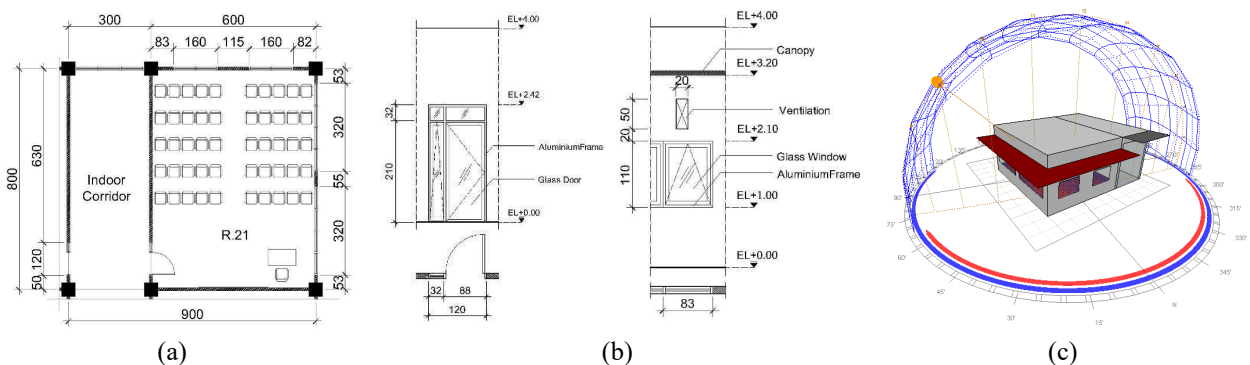**Figure 1.** (a) GB V location, (b) R.21 location, (c) R.21 condition

Figure 2. (a) R.21 layout plan, (b) door & windows detail, (c) Ecotect simulation condition

Several variables also applied for simulation. Indonesia has 10.000 lux for sky illuminance [7], with minimum standard illuminance for classroom is 300-750 lux [10]. Besides light levels, daylight factor also been used to determine the natural light quality inside the room. Day light factor is the ratio of light level inside a building to the light level outside the building, with standard minimum 2% for office room [11]. Thermal Comfort Prediction (PTN) standard for tropical country is more suitable with 0,749 of mean temperature of that place, plus 5,953, because every region in Indonesia has different climate condition so that the thermal comfort for very people on each region is different [12]. Since Bengkulu has 26,75^{O}C mean temperature and 77,8% annual humidity (climate-data.org), 26 ^{O}C will be used as a maximum standard of temperature.

3. Result and Discussion

Discussion of the study did by description of simulation image that indicate by the colors. Image shown is the room plan at level 60cm above the floor that assume as working area. Visual comfort will be identified by explaining the light levels of the room in lux and light factor in percent. Thermal will be identified by explaining the temperature of the room in degree celsius.

 A. Visual Comfort

Ecotect simulation for daylight analysis showed that the average value of annual natural light for R.21 GB V UNIB is 630 lux and 6,3% of daylight factor. This annual light is already met the minimum standard of lighting inside a classroom and can be said a well-lit so artificial lighting is not required generally. The highest light in the room is 2000 lux located in A room-corner (indicated by yellow color in figure 3.a) where a glass door faced to indoor corridor exist. It's somehow strange and maybe there's an incorrect data reading in simulation. But, since A corner area is not an important area in the room, so it can be ignored. Another area that received high light is in C corner, which is around 1.000 lux. Most of area in BC side has 800 lux of daylight

and 8% of daylight factor. This light level is good enough. But, activity in this area should be careful because can make an uncomfortable condition such as glare when the student doing writing/drawing task on the white paper. Light level at the center of the room is mostly dominate by 550 lux and 4,5% of daylight factor. This area, where mostly students sit and doing activity inside the room, is comfortable enough and can be said effective for learning activity. While AD side area, mostly has 500 lux of daylight and 5% of daylight factor. Even though this area is received the lowest light among the room, it's still meet the minimum standard of light needed in classroom.

Overall, R.21 GB V UNIB can be said that comfortable enough in term of visual. Around 1/4 – 1/3 area of the room is met the minimum standard of classroom lighting. It can be happened because there're a lot of windows in east and north wall, with ratio 1: 4,5 of the room square area. But, one thing to be careful about is the excessive light inside the room because it can lessen the effectiveness of learning activity in classroom. This problem can be solved by proper shading design.
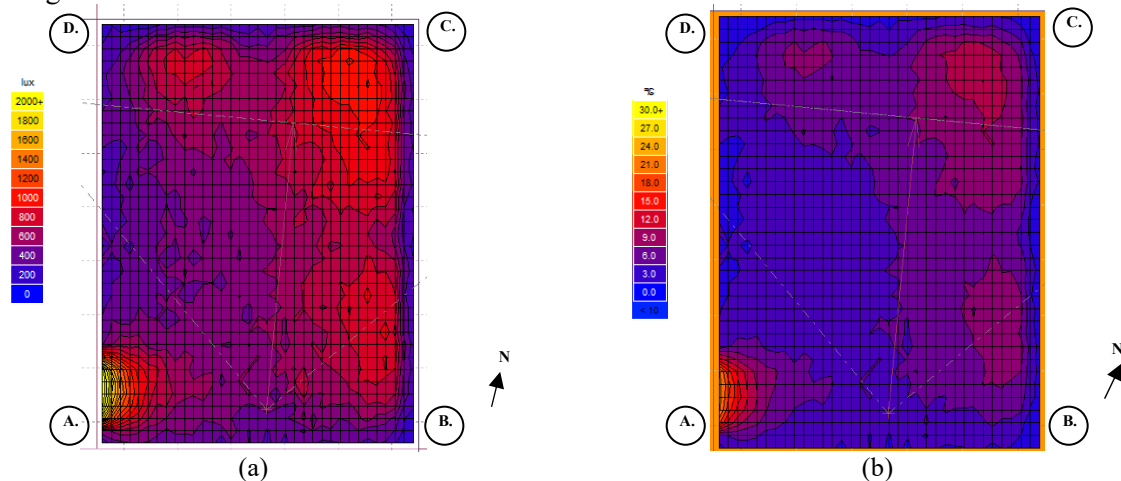

(a)   (b)

Figure 3. Daylight Simulation of room plan at el+60cm (a) Daylight level, (b) Daylight factor

B. Thermal Comfort

Ecotect simulation for thermal analysis showed that the average value of mean radiant temperature for R.21 GB V UNIB in April at 9.00 am is 27,65°C, in April at 12.00 pm is 29°C, in April at 3.00 pm is 28,7°C, and in September at 9.00 am is 23,43°C, in September at 12.00 pm is 25,25°C, in September at 3.00 pm is 24,99°C. It can be seen that mean radiant temperature for R.21 GB V UNIB in April is quite high with average temperature 28,45°C for whole day when this class is used for learning activity. While on September, mean radiant temperature for R.21 GB V UNIB is quite low with average temperature 24,56°C. So, average temperature of R.21 GB V UNIB annually is 26,6°C. This result makes R.21 GB V UNIB is not comfortable enough because exceed the Thermal Comfort Prediction (PTN) standard for Bengkulu area. R.21 GB V UNIB received highest heat at midday (12.00 pm) either in April or September. While BC side is the most uncomfortable area because receive the highest heat for whole day. It happened because BC side wall has numbered of glass windows that faced to the east. The highest heat in BC side is 29,3°C on April and 25,7°C on September. So, average temperature in BC side annually is 27,5°C. Mean radiant temperature at the center of the room is mostly dominated by 28°C on April and 24,5°C on September. Average temperature at the center of the room annually is 26,25°C, which is still exceeded the standard. D corner is an area that received lowest heat in the room. Temperature at D corner is 27,3°C on April and 23°C on September. So, average temperature in BC side annually is 25, 15°C, which is comfortable enough. Even though there's several glass windows in CD side wall. But, since this wall faced to the north, it doesn't received so much heat.

Table 1. Mean radiant temperature simulation result

Month	Hour	Temperature
April	9.00 am	27,65 °C
April	12.00 pm	29 °C
April	3.00 pm	28,7 °C
September	9.00 am	23,43 °C
September	12.00 pm	25,25 °C
September	3.00 pm	24,99 °C

Overall, R.21 GB V UNIB can be said that not comfortable in term of thermal. It can be happened because there're numbered glass windows in east wall that bring a lot of heat for a whole day. To overcome the excessive heat, utilization of natural airflow can give cool effect for building user. Besides that, a proper design of shading or skin façade also can help reducing the heat transfer from outside to inside of the room.
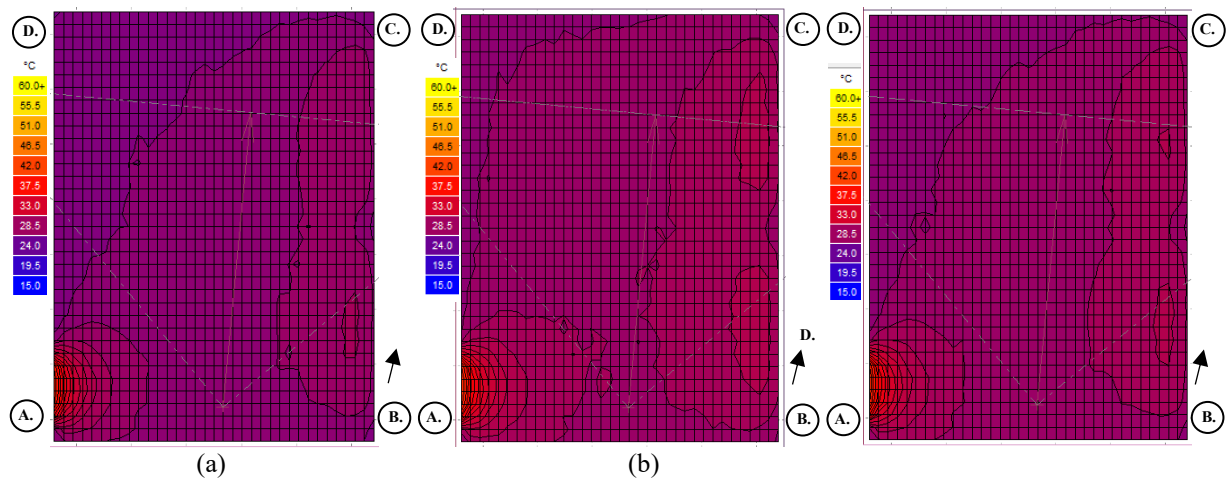

Figure 4. Thermal Simulation of room plan at el+60cm in April. (a) Mean radiant temperature at 9.00 am, (b) Mean radiant temperature at 12.00 pm, (c) Mean radiant temperature at 3.00 pm
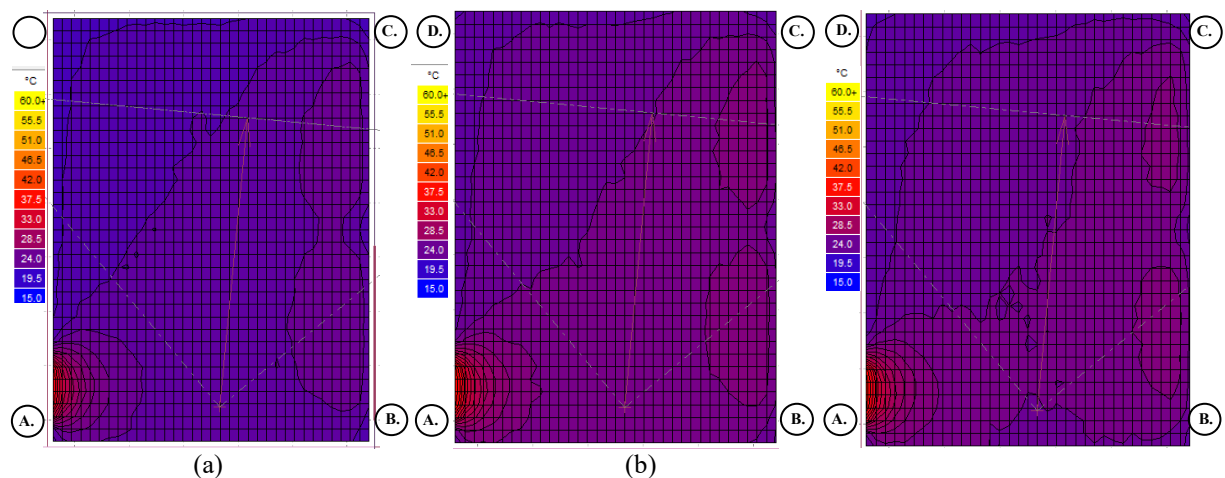

Figure 5. Thermal Simulation of room plan at el+60cm in September. (a) Mean radiant temperature at 9.00 am, (b) Mean radiant temperature at 12.00 pm, (c) Mean radiant temperature at 3.00 pm

4. Conclusion

From the simulation did above, can be concluded that:

- The presence of numbered glass windows in east wall of R.21 GB V UNIB bring in a lot of light along with heat.
- R.21 GB V UNIB is still not effective enough as a learning facility because the excessive heat inside the room is not comfortable enough in term of thermal. Moreover, although the lighting inside the room is already met the minimum standard, the excessive light inside the room should be careful because can make an uncomfortable condition in term of visual such as glare.

Some recommendation to optimize the comfortable of R.21 GB V UNIB is utilization of natural ventilation to overcome the excessive heat and a proper design of shading or skin façade to reducing the heat transfer and excessive light. This recommendation can be a further research to optimize the effectiveness of R.21 GB V UNIB and another classroom as a learning facility.

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