A Study On The Influence Of Illuminance Quality To Student's Performance Of Visual Activities: Case Study Of Architecture Studio Room In Universitas Islam Indonesia

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Abstract

This research aims to measure and evaluate the level of illuminance quality in architecture studio room in relation to the achievement of standard performance and minimum visual comfortableness that should be fulfilled. This study also explores the effect of both illumination quality and quantity to the students physical and psychological performance in conducting visual activities in the architecture studio room. This evaluation will also evaluate the deviation between perception of brightness of users and data measurement by using device related to the achievement of illumination standard of the room. This research is conducted with mix method of quantitative and perceptional with correlational method. The study used empirical data and information from students as the object of research through questionnaire survey and actual data by measurement using luxmeter device to measure the quantity of luminance in the studio room. The data collected indicates that the performance of visual activities that should be achieved require a quite high illuminance quality considering the long duration and continuous activities. This research also explores the importance of determination of visual standard based on the variation of activities compared with the determination of space definition to ensure that all visual activities can be done with optimum performance. The findings indicated that perception of brightness and the adequateness of lighting level in determining visual requirements are two different things in which the adequateness of illuminance level is numerical standard that is determined based on visual observation. The determination of illumination adequacy which is made based on individual perception of brightness may lead to various visual performance standard that may potentially cause illuminance deficiency and as a result may cause various symptoms of eyes fatigues that lead to the decrease of visual performance.

Keywords: luminance quality, perception of brightness, continuous visual performance, Architecture studio room.

Introduction

Various strategy has been prepared by many educational institutions in order to achieve their goals to achieve the best graduates including by improving the quality of education facility or the students. This is important to be done considering that learning process is a series of

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activities that involve space, time, and experience. The learning outcomes that the students achieve are the accumulative contribution from the whole aspect of learning in which each factor plays its role.

One of the important factors that should be considered by the education institution is about how to create a good learning environment by increasing the performance of comfortableness in the learning space so that the learning activities can be done optimally. One of the comfortableness parameter that should be fulfilled is visual comfort. This is important because most of learning activities use visionary sense (eyes) to receive information and knowledge.

Universitas Islam Indonesia is one of the oldest higher education institutions in Indonesia that have architecture department with various learning activities ranging from simple to complex activities, which are done in almost 24 hours a day. The conducted activities can be influenced by the condition of the place where the people do their activities. One of the most dominant room for activities in architecture department of Universitas Islam Indonesia is architectural design studio room. The room has complex learning activity with average duration of compulsory activity for about 200 minutes per day, which requires good visual quality. In conducting numerous activities, students need balance luminance because it may directly and indirectly can help the students to do paper and computer based activities well (Illahi, 2013). This research will explore about how the consistent light intensity in the working area can influence cognitive skills in continuous learning activities.

Research Objectives and Scopes

This research is conducted in the special scope of Architectural Design 6 Studio Room that is divided into 10 classrooms where the learning activities were conducted for about 24 hours in a dedicated room. Meanwhile, the substantial scope of this research is to measure, compare, and evaluate the quality of luminance in the architectural studio room in relation to the achievement of performance standard and minimum visual comfort that should be fulfilled. In addition, this study explored the impact of quantity and quality of luminance towards the physical and psychological condition of students in conducting visual activities in the architecture studio room.

Figure 1. The Location of Architectural Design 6 Studio Room.

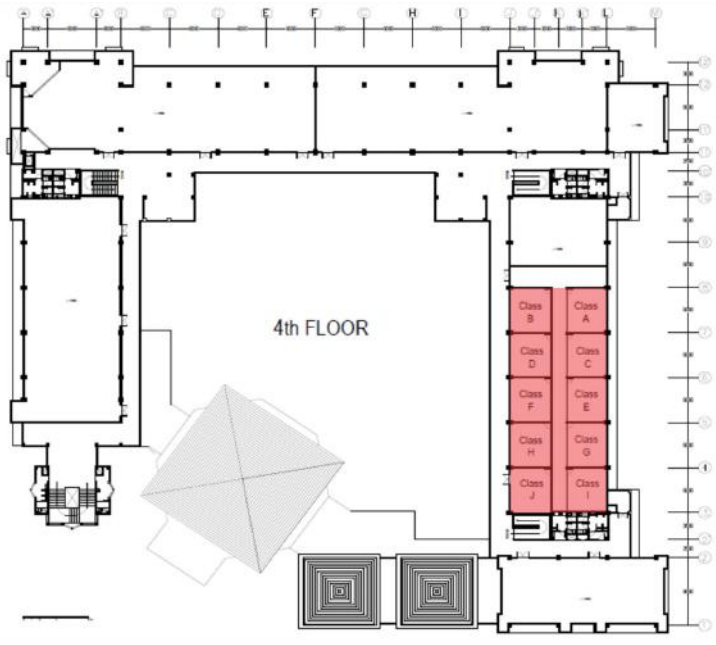


Figure 2. The Position of Room in M. Natsir Building .

This research is expected to contribute some consideration of evaluation for education institution about the fulfillment of luminance standard for learning room. It also may provide knowledge about the difference between luminance standard and perception of brightness so that the justification for quality fulfilment is not decided based on subjective evaluation but based on calculation and measurement using specific device.

Understanding about good luminance need fulfilment will help the activities in a room to achieve optimal performance. This can be achieved by the evaluation of opening size, number of artificial luminance that is adequate for the room and material optimum for light reflection.

Review on Architecture Studio Room

Architecture Studio Room is a place bordered by walls, floor, and covered ceiling used for learning and teaching activities in architecture department that can be used for 24 hours without any limitation.

Natural luminance is the most efficient, cheap, and abundant from direct sunlight, clear sky, cloud, or reflection from the below surface or the building around (Lechner, 2001). Whereas, artificial luminance owns achievement and flexibility that allow designer to ignore the position of windows and it usually has consistent need of luminance.

The architectural studio room that becomes the object of the research uses the combination of natural luminance from direct sunlight and sky light as well as artificial luminance from fluorescent light (FL tube) T8 type surface mount. The studio is a big room with semipermanent white painted partition with windows penning and bouven in both sides. The dominant color of the room is white tusk with brown wooden furniture and some room elements such as poster, window frame, rack, and colorful panels.

Review on Luminance and Perception of Brightness

Room luminance influences the room functions and activities of the users so the quantity of one room and another room may be different, depending on the kind of activities of the room user. Followings are the standard of room luminance:

Table 1. Average level of luminance and recommended color temperature (Source: SNI 03-6197-2001).

No.	E (lx)	Visual Activities
1.	20	Minimum value in interior spaces, e.g. working areas. Illuminance level required for recognizing facial features
2.	200	Minimum illuminance for workplaces in continuous use
3.	2.000	Maximum illuminance at standard workplaces
4.	20.000	Illuminance level for special visual tasks e.g. in operating theatres

Table 2. Luminance Level for Educational Building (Source: Staff, 2004)

No.	Room Function	level (lux)	Color Temperature		
			Warm White <3300K	Cool White 3300-5300K	Day-light >5300K
1.	Class-room	250 lux		v	v
2.	Draw-ing Room	750 lux		v	v
3.	Color check-ing	750 lux		v	v

Table 3. Typical illuminance levels E in interior spaces (Source: Ganslandt and Hofman).

No.	Type of Rooms	Luminance Level (lux)
1.	Classrooms, tutorial rooms	300
2.	Classroom for evening classes and adults education	500
3.	Art rooms	500
4.	Art rooms in art schools	750
5.	Technical drawing rooms	750
6.	Practical rooms and laboratories	500
7.	Handicraft rooms	500
8.	Teaching workshop	500
9.	Computer practice rooms (menu driven)	300
10.	Preparation rooms and workshops	500
11.	Circulation areas, cor-ridors	100
12.	Student common rooms and assembly halls	200
13.	Library: reading areas	500

The level of lighting in the room is based on two reference of values, i.e. illuminance and luminance. Illuminance is measurable quantitative values to determine the visual gain standard of the room in lux unit while luminance is level of brightness determined by eye observation based on the comparative reference. Luminance is the one that is usually used by the society to determine the quality of illumination in a room in a subjective or perceptive way.

Review on Activities

Activity can be defined as activism, action, work or one of the doings conducted in every part of an institution including in educational institution (KBBI, 2016). In educational institution, there is always the activity of learning and teaching in which the activism between the teacher and students become the indicator of learning success.

The learning activities can be divided into followings (Sardiman, 2008):

1. Visual activities: reading and observing
2. Oral activities: stating, formulating, asking, giving suggestion, giving opinion, and discussion
3. Listening activities: listening to presentation and discussion
4. Writing activities: writing report and making notes
5. Drawing activities: drawing, making graphic, map, and diagram
6. Motor activities: conducting experiment
7. Emotional activities: showing interest, feeling bored, having fun, spiritful, enthusiastic, brave, calm, and nervous.

In the case of studio room, the activities that mostly happen in the room include visual, oral, listening, writing, drawing, and motor activities. Sample of activities that happen in the studio room are reading, observing, drawing, listening, writing, and making maket.sw

Complexities of activities highly require comfort quality of the studio room. Every activity can be done with various sense of the body so that comfortableness for all senses when conducting observation or learning should be fulfilled. When a person is using her or his eyes for observing, then the eyes should get comfortableness in seeing something. Thus, the level of learning success can be achieved.

Visual activity is the action that prioritizes the vision process. The performance of visual activity can be implemented in the visual object (Lechner, 2001). Followings are some basic factors that influence visual activities:

1. Activity: size/distance or proximity, limited time, level of brightness, contrast, closeness.
2. Illumination condition: level of illumination, ratio of brightness level, glare.
3. Observer: eyes condition, adaptation, level of consciousness.

Research Methodology

This research uses a mix method of quantitative and perceptional with correlational method. This study used data and descriptive information from students as research object. The data were gathered through questionnaire and empirical data. Measurement device was used to measure the quantity of luminance in the studio room and then the connections between the two data were correlated.

The research location is architecture design studio room, architecture department, faculty of civil engineering and planning, Islamic University of Indonesia. This room consists of 10 classrooms used by students of semester six in the academic year of 2015/2016. These classes were used at least 200 minutes per day. The classes were used in the morning, day time, afternoon, and evening. The class facilities are tables, chairs, cupboards, windows (2-4 windows with the size of 1 meter x 1 meter), and lamps (8 lamps to illuminate two classrooms in the west and eastern part).

The subject of this research is students from semester six who are spread in 10 classes with observation for about one semester. This research took 40 respondents from total 120 students representing 10 classes with balance range of population between male and female students. The students are relatively in the same age (20-21 years old) and they do not have visual disability and are in a healthy condition.

The room measurement was conducted by using measuring device to measure the size of the class. The measurement of the illumination level was done using luxmeter and the activities observation with direct documentation with camera in 9 main points. The determinations of

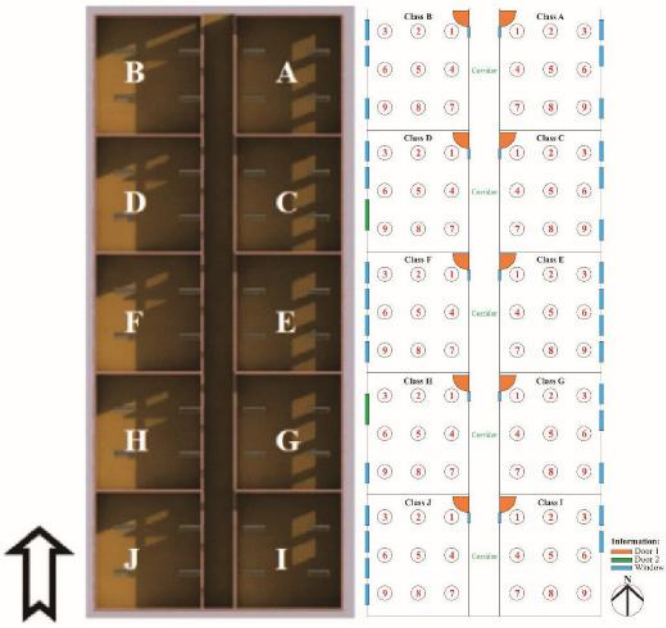


Figure 3. Location of Research & Distribution of Measurement Points.

the points were done by dividing each classroom into 16 segments of space with 9 points located in the areas that are spread evenly. Some analyses conducted in this research are followings:

1. Comparing data from the measurement of illumination level in studio room in lux unit with standard illuminance that should be achieved.
2. Researcher analyzed brightness perception of students based on the questionnaire with level of illumination based on the formal standard.
3. Researcher analyzed the data of illumination level measurement from the students questionnaire related to visual discomfort.

Result and Discussion
Room Illumination Level

The level of illumination quantity for the architecture studio room was measured using luxmeter in there period of time in the 10 classrooms in the morning, daytime, and afternoon. The level of illumination in each classroom was measured in the 9 points that are spread even-

Table 5. Illumination Level of Room.

No.	Class	Time	Point									Existing Conditions	Position
			1	2	3	4	5	6	7	8	9		
1.	A	Morning	141	197	208	258	283	210	209	191	208	Sunny	East
		Daylight	53	151	126	212	195	186	148	221	119	Sunny	
		Afternoon	106	127	41	159	183	146	139	166	128	Cloudy	
2.	B	Morning	200	216	119	255	307	231	226	163	150	Sunny	West
		Daylight	226	176	131	226	252	331	84	136	147	Sunny	
		Afternoon	112	223	182	173	252	231	174	208	170	Sunny	
3.	C	Morning	48	163	63	221	261	218	138	157	148	Sunny	East
		Daylight	45	146	61	180	219	190	111	160	146	Sunny	
		Afternoon	114	132	116	147	176	134	83	146	111	Cloudy	
4.	D	Morning	104	152	133	98	196	168	121	132	121	Sunny	West
		Daylight	109	145	132	97	189	167	121	136	129	Sunny	
		Afternoon	109	157	132	79	178	156	111	128	117	Cloudy	
5.	E	Morning	115	160	104	207	240	168	132	226	164	Sunny	East
		Daylight	48	78	138	62	177	83	131	116	119	Sunny	
		Afternoon	107	132	92	127	168	136	100	146	106	Sunny	
6.	F	Morning	147	176	158	257	253	236	252	238	188	Sunny	West
		Daylight	148	186	170	316	319	255	307	330	238	Sunny	
		Afternoon	162	191	162	409	489	283	403	441	278	Sunny	
7.	G	Morning	157	189	132	237	285	203	204	111	203	Sunny	East
		Daylight	132	165	119	210	222	172	116	113	150	Sunny	
		Afternoon	137	187	145	195	207	145	142	147	132	Cloudy	
8.	H	Morning	167	199	177	320	296	244	217	258	227	Sunny	West
		Daylight	171	219	206	352	331	303	274	349	308	Sunny	
		Afternoon	195	246	180	272	432	282	308	320	275	Sunny	
9.	I	Morning	142	173	131	89	225	173	149	147	142	Sunny	East
		Daylight	56	143	138	195	200	172	146	190	150	Sunny	
		Afternoon	140	148	117	180	189	153	120	105	127	Sunny	
10.	J	Morning	110	140	141	204	200	182	75	132	68	Sunny	West
		Daylight	125	164	171	230	296	212	130	225	98	Sunny	
		Afternoon	107	146	165	210	298	200	85	193	68	Sunny	

ly to the whole room with data collection in the height of 80 cm (workplane).

The illumination that is measured is the combination between natural and artificial illumination. Natural illumination in the room was obtained from the opening of windows in the eastern and western part of the room. Whereas, the artificial illumination for each class was obtained from 4 lamps TL 2 x 18 W with the height of 4 meter above the floor surface.

Measurement result on the illumination level of room indicated a diverse data for each class. Generally, the room orientation did not contribute significant difference between the rooms in the eastern parts and the rooms in the western parts because the natural illumination was dominated by sky illumination. This happened because the design of building cover mostly use shading elements that reduce penetration from direct sunlight and the distance between building is relatively not far (around 40 meter) and the vegetation around the building also became the shading.

Different time of measurement between morning, daytime, and afternoon time indicates significant variation of illumination intensity with the highest difference of 0.145 in room A. The result of measurement to the whole classrooms showed minimum intensity values of 41 lux in room A in the afternoon and the maximum value of 489 lux in room F in the afternoon. From the measurement result, it can be descriptively concluded that:

1. Number of illumination intensity in the room is various between one part of the room with another part.
2. The quality of illumination of room between one room and another are relatively different.
3. The quantity of luminance in one room change significantly along the transition of time from morning, daytime, and afternoon
4. Generally, the intensity of studio room illumination is still far under the minimum standard that should be fulfilled, which 750 lux.

Uniformity of Room Illumination

The lowest value of illumination spread in the room is 0.184 in room C in the morning time. Whereas, the highest value of uniformity is in room G in the afternoon for about 0.638. The low value of uniformity indicated high contrast in the room and less spread quality of illumination in the room.

Room performance can be defined as the highest achievement of a room in fulfilling the functional need (Mangkunegara, 2000).

Figure 4. Illumination Level of Classrooms A,B,C,D,E (Source: Researcher's Analysis, 2016)

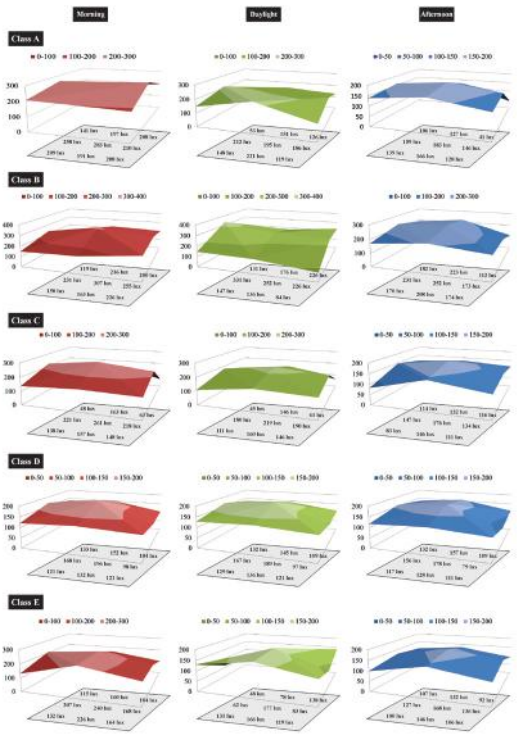
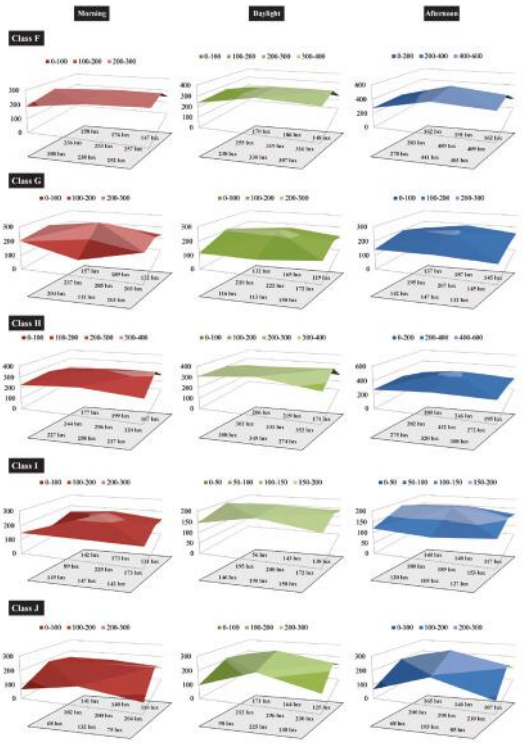


Figure 5. Illumination Level of Classrooms F,G,H,I,J



Achievement result of illumination level based on the measurement in the 10 classroom in the studio show the average luminance of (EN) 178 lux. The value was obtained by combining the average of each class in the morning, daytime, and afternoon. The lowest average value is 111 lux in room E in the daytime and the highest average value is 313 lux in room F in the afternoon. The average illumination value (EN) that can be used as guidance considering the visual performance is needed in the whole part with the same quality in the class.

When compared with the analysis of visual performance according to standard of illumination then the average intensity is 178 lux. It can be concluded that it is only adequate to do simple visual activity, which is not continuously. According to the standard of CIE, the continuous visual activity should be at least 200 lux. Whereas, the need for simple activity can be varied around 200 to 500 lux depending on the characteristics.

The minimum standard of illumination of classroom according to SNI is around 250 lux. Thus, it can be concluded that the studio room is only optimum to be used to conduct activities with certain level of difficulty as follows:

1. Seeing text with standard size (font 12 or more), black and white, standard type (simple and easy to read font), without symbol (using standard notation without bold character).
2. Seeing black and white graphic, straight type with standard property (not more than two compositions such as dash (-) and dot (.).
3. Duration of short and discontinuous activities e.g. 5 minutes reading with pause and then continue to read again.
4. Working using computer with basic colored keyboard with variation of LED. The size of laptop is not more than 14 inches with standard mouse and short duration of max 10 minutes.
5. Doing activities with communication tools through gadget keypad with touchscreen and short duration of max 10 minutes.

If the students conduct other activities with higher complexity of visual observation or conducting simple activities with longer duration, they may experience unideal vision where the visual object cannot be seen optimally and cause eyes to work harder and may lead to eyes fatigue.

Some references stated that the drawing room should have minimum illumination intensity for at least 750 lux (Staff, 2004) and (SNI, 2001). This standard refers to the illumination need fulfilment for students' visual activities with high complexities i.e. drawing. Although the visual activities conducted in the rooms are relatively various, the condition of natural illumination and artificial are relatively static which make the output of illumination re-sulted became static (non adjustable). Thus, the illumination standard should fulfil the minimum standard with the highest value of 750 lux so that all visual activities in the classroom can be done optimally.

The average condition of illumination that is under the minimum threshold makes it difficult to conduct various activities in the architecture studio room and it is difficult to observe the complexity of visual object. Activities with high complexities and level of difficulties are as follows:

1. Reading text with unstandardized size (Font 8, 9, 10, 11) with low saturation colors (pastel colors) and high saturation (bright colors), unstandardized text type with more complicated artistic shape and uneasy to read, reading text with combination symbol (+,.*²123), using notation, bold, etc.
2. Reading graphs with low saturation (pastel colors) and high saturation (bright colors), graph with curve or with unstandardized property (more than two compositions e.g. dash, dot and slash).
3. Reading long text with long duration continuously for more than 30 minutes
4. Identifying dimensional object, making comparison and graphic clarification
5. Reading pictures shading and unstandardized graphic notation, specific marker, density, scale, and proportion comparison
6. Identifying graphic with gradation property characteristics for color, density, thickness, and size
7. Conducting activities using computer with the screen size less than 14 inches, using specific type keyboard layout with duration of activities more than 30 minutes.
8. Identifying notation, symbol, line, and architectural graphic shapes with quite high details.
9. Conducting activities using handheld communication with keypad non touchscreen qwerty type with duration of activities more than 30 minutes
10. Arranging and composing building with 3 dimension scale (maket) with stiff materials and uneasy to cut (such as kappa, balsa, etc.), materials with dark color, material with thickness more than 2mm and shaping the material using special cutting tools.
11. Arranging model with the help of sticking tools or glue with relatively fast drying duration
12. Evaluating the quality of printed document with combination of graphic, text, shapes, and color in the same time continuously and thoroughly.

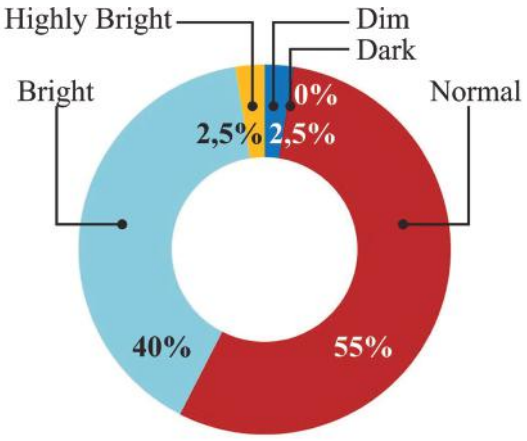
Difficulties that happen among the students while doing visual activities above are caused by unfulfilment of standard luminance that makes the eyes work harder and in uncomfortable accommodation condition. If this condition occurs in the long duration (in average 5.4 hours/day), the eyes may experience fatigue as felt by 95 % of the respondents. In this condition, the visual performance of students became not optimal.

Besides the physical impact, recurrent eyes tiredness and difficult identification process of detail and complex visual objects can also give negative psychological impact. Longer time needed to finish the complex visual activities will decrease productivity and performance along with the increasing deadlines, quality of product and work.

Student's Perception about Brightness

Data collections about the perception of students were done to 40 students' representative of each class. The data collection includes some information about student's perception about the illumination quality of the studio room based on existing condition. According to the finding, 97.5 % of respondents stated that the condition of the room with below standard luminance was enough for them to do various activities in the studio. Only around 2.5 % students stated that the room is not bright enough.

Graphic 1. Students' Perception about The Level of Illumination.



The result of this observation indicated that perception of brightness cannot be used the guidance in fulfilling the standard need of luminance inside the room and the brightness perception does not necessarily means that the need of visual performance has been met. This is proven by the fact that based on the result of measurement in the field, the quantity of luminance in the studio room is far below the minimum standard of 750 lux.

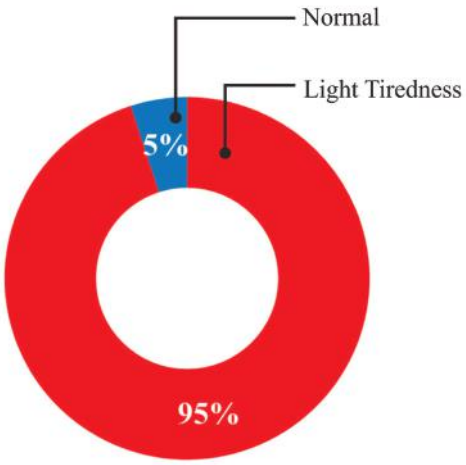
The brightness perception is gained by the respondents based on their daily experience related to the visual activity inside the room. Compared to the level of luminance in their residence, most of the respondents (55 %) stated that the studio room is brighter, while 18 % stated that the level of luminance in the studio is the same with their residence, and 27 % stated that the studio is darker than their home. This experience can be the guidance of respondent in determining the perception that the studio room is bright enough because subjectively, the brightness sensation in the studio is higher than the brightness sensation at home.

Through observation toward students; activities in the studio room, it is found that the average time spent by the students in the studio is around 5.4 hours per day for one semester. Some students even spend up to 24 hours in certain period especially next to submission deadlines and examination.

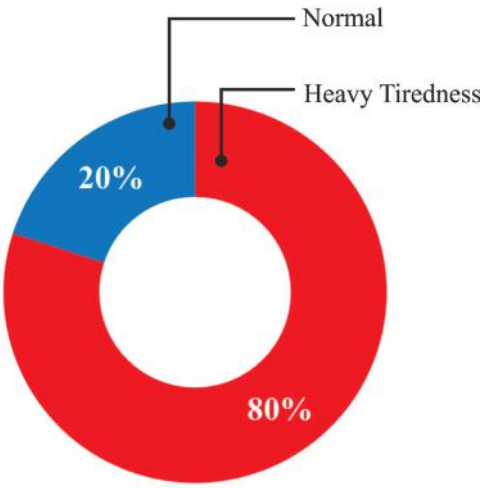
High duration of the activity requires good eyes performance. However, the relatively low level of illumination in the studio room and the unfulfillment of luminance standard can make the eyes work harder. This condition may trigger eyes tiredness that happened to almost all respondents. Those symptoms can be categorized into two categories i.e. light and heavy fatigue symptom. About 95 % of respondents experienced light eyes tiredness and 80 % of respondents experience heavy eyes tiredness. The symptoms are as follows:

1. Light tiredness. The symptom of light tiredness are dizziness, eyes fatigue, watery eyes, eyes irritation, blur vision, and tired eyes
2. Heavy tiredness. The symptoms of heavy tiredness stated by the respondents are sleepiness, losing concentration, anxious feeling, depression, migraine, headache, and vertigo.

Graphic 2. Light Tiredness (Source: Questionnaire Data, 2016)



Graphic 3 Heavy Tiredness (Source: Questionnaire Data, 2016).



Conclusion

From the discussion, it can be concluded that the brightness perception and the level of luminance adequacy for visual activity performance are two different things. The adequacy of illumination level is numerical standard that is determined based on the type of visual observation while the brightness perception is subjective perception with various values based on comparison to other experience.

The measurement analysis of illumination level in the studio room that became case study in this research indicated that there is significant deffiency. The average level of illumination, which is only around 178 lux, is only enough for basic visual activity with low complexities and not for continuous activity. However, the need of illumination for studio room with the diversity and complexities of activities need minimum luminance value that is much higher than 750 lux.

Deficiency in illumination level made the visual activities of students, which is complex and has long duration become not optimal. Besides, luminance deficiency may also become the causes of eyes tiredness symptom in low and high level that in the end can make the visual activities in the studio not running well.

The main factor that is considered as the main cause of the luminance deficiency is the anatomy of rooms, orientation, cover composition, and inaccurate use of artificial illumination when it is correlated with the room function as architectural design studio room.

The most effective recommendation for short term is adding and replacing type of artificial illumination with a more accurate photometry so that the number of luminous flux (lm) that is produced will fall exactly at the workspace. For long term, the use of natural illumination is highly recommended. The addition of opening dimension with daylight control can be the most effective ways for existing building so that the quantity of sky light entering the room will be more optimal without giving negative impact such as sun heating and glaring in the room.

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