บทความวิจัย

DEVELOP THE ARCHITECTURAL DESIGN PRINCIPLES IN ARTIFICIAL LIGHTING IN A BED AREA FOR SENIOR LIVING

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ABSTRACT

The environmental intervention by artificial lighting principles, such illuminating with yellow light and shine in appropriate direction play important roles in senior care in bed area. This study is concentrated on the principles of artificial lighting in senior activity correlated to bed space planning which its objective is able to promote a higher level of seniors' vision for well-being in their space. To clarify artificial lighting principle, the research is setting up by surveying on-site and lighting modelling for analysis. The result of the research offers the alternative principle, conceptual improvement in invented lighting, and the averaged values of illumination for physical standard requirement.

Keywords: senior, Bed space, artificial lighting

Introduction

Vision in seniors

Vision loss in elders is caused from their protein deterioration. It results that lip eyes fall down a little, produce more tear and more clouding eye lens to decrease the range of elders' vision by 25% as the age of 50. After then, it remains 50% when they are 70 years old. As a physical change, the elders can see the warm color tone, such yellow or red (Joseph, 2006). Seniors' visual ability in low lighting decreases together with more visual disturbances such as spots & floaters. When they are at the age of 80, most elders already have or will develop cataracts which lead to color vision declines,

and visual fields begin to narrow (Heiting, 2015). Hence the standard lighting level and its details are necessary applied to compensate the vision declined in seniors.

The existing standard and recommended lighting level.

The previous reports form Illuminating Engineering Society of North America (IESNA) issues the lighting standard for the criteria which is divided in sub-functional area in a senior resident's room.

This article reviews from the different recommendations of the artificial lighting from IES for senior resident, by comparison among in 3 versions in the lighting standard from VDI/ VDE Guidelines 6008-3, Barrierefreie und behindertengerechte Lebensräume (Accessible Living Spaces), IESNA in the Residents' room (Table 1), and recently, the recommended light levels by age group between 60 to 80 years old (Figure 2).

Table 1 Recommended practices in illumination values: IESNA Recommended Practice for Lighting and the Visual Environment for Senior Living (IESNA, 2001)

Area	Light scenario	Illumination intensity	Light color	Type of lighting
Residents' Rooms	care light bed level (85 cm above floor)	300-500 lux	warm white	direct/indirect, depending on care case two-component lighting
	reading light, work light bed level/reading level (if necessary, separate additional lighting)	300-1000 lux	warm white	direct/two-component lighting
	living area light, close to floor	100-500 lux	warm white	direct/indirect
	Night light, close to floor	50-100 Lux	warm white	indirect
	monitoring lights for care staff at night, close to floor	approx. 5 Lux		

Referred to the comparison of the average and recommended light in Lux unit (referred to the table of ANSI/IESNA RP-28-2001) for senior living unit (Waggoner. 2005.). When this report is interpreted into a diagram format (Figure 1), it can figure out clearly that the value of 322.8 luxs is the average value of illuminance for ambient lighting in

whole area which suitable for senior vision. And the value of 807 luxs is averaged for task lighting to make elders do the heavy duty in the specific area such reading or doing hobbies on their bed. Although these values of illumination meet basic elder requirement, elders need higher level of illuminance because of the visual decrease related to older age. Figure 2 shows the recommended light levels by age group between 60 to 80 years old, it found that the senior in the age of 80 need the more value of illuminance approximately 1.5 of the 60 years old elders do.

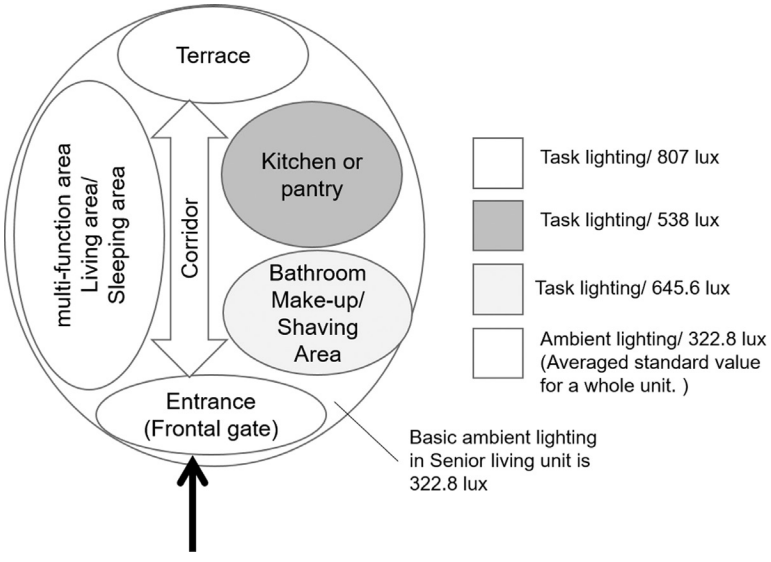

Figure 1 Converted diagram of the standard values of illuminance (luxs) for senior housing unit from Table ANSI/IESNA RP-28-200.

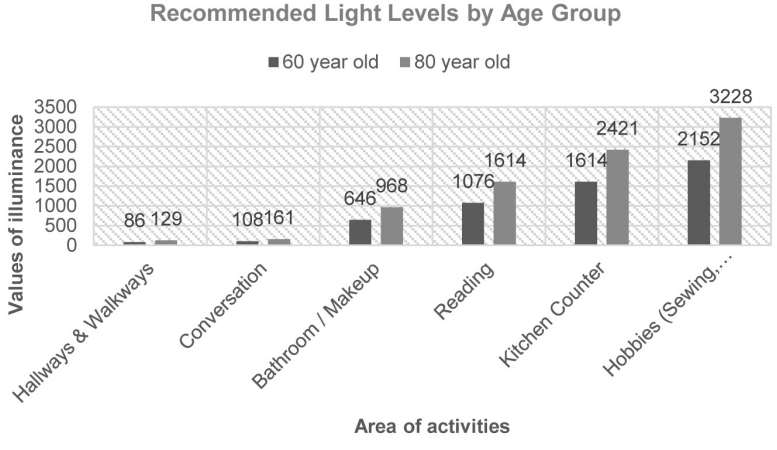

Figure 2 Recommendation of light level by age group (Brielmaier, 2017)

Situation of senior housing in Thai aging society.

Similarly in the other trend of the world that a country approaches to an aging society, Thailand is one is expected to be next 18 years. In 2035, 25 percent of all Thai population is the senior group. (Institute for Population and Social Research, Mahidol University, 2013). Aging societies need to modify domiciles to accommodate the changing needs of the elderly household members. It need to be elderly-accessible, and this may require modifications to rooms (Pramote Prasartkul, 2015)

In particular, the bed area where the seniors spend their time do more activities when they get elderly. Artificial lighting is one of the assisted living facility to promote elder vision to be self-reliant and physical therapy in seniors in the bed space. The environmental intervention by artificial lighting principles, such illuminating with yellow light or shining in appropriate direction to seniors activities, plays important roles in senior care in bed areas.

Statement Issue

This study is concentrated on the principles of artificial lighting in senior activity correlated to bed space planning. The research objective is to promote a higher level of seniors' vision for well-being in their space. This research investigates in the comprehensive review in elder's activity, existing artificial lighting principles concerned the position fixture, direction, and its consistent values of illuminance (luxs) from applying principles.

To clarify artificial lighting principle, the research is implemented in 2 ways: setting up by surveying on-site, and lighting modelling for analysis via the case study Sawakanives as the acceptable one of the typical senior apartment unit in Bangkok for middle-income elder residents, is selected as a paradigm to discuss.

Research Methodology

Literature Reviews

Existing Types, Principles of lighting.

Like the lighting for other aged- range of people, senior need the similar lighting disciplinary. In general, artificial lighting is divided by functions in 3 outstanding lighting types: ambient, task and accent. An ambient light act that elders can see the whole area atmosphere. The ambient lighting setup is the approximately middle position

in the living space. As the task types light at the specific point with the higher level of light for performing visual task, for example reading or doing the hobby on a table. The accent light is always called the decorative light which proposed for highlighting an artwork or architectural feature. Its direction creates a point of interest in a room (Figure 3). However, before planning the light in living room for elders There are some basic lighting principles which are realized that: providing a sufficient ambient light near the computer, monitoring where senior is using, eliminating reflect light while seniors use, and bounce light off the upper wall and ceiling.

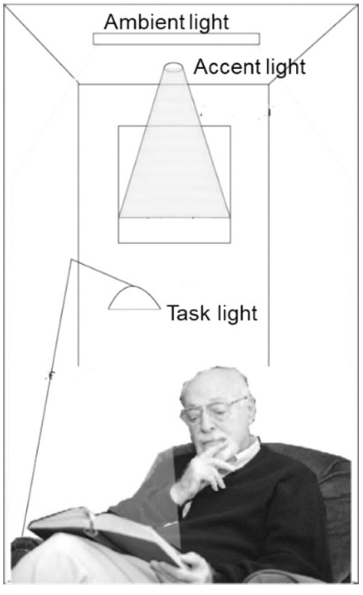

Figure 3 The Existing division of indoor artificial lighting types. (Waranyoo Siriwan, 2015)

Existing principles in artificial lighting in a bed space.

Due to the physical change effect on elders, do activities slower and easily fatigue. The sleep in seniors decreases, they are easily stimulated and disturbed from surrounding (Jittisak Poosrisawat, Takada Minako, 2009). It impacts that seniors spend longer hours on bed all day. The bedroom is redefined to be as a place not only sleeping, but working and relaxing in hobbies (The Center of Design for an Aging Society. 2006.), the result shows that elders' movement should be high safety and comfortable as being at the bed area. There has some realization that (IESNA. 2009):

1. Ambient light is used to alleviate eyes fatigue, helps elders reading or watching easier.

2. Task lighting in bedroom should be adjustable and more comfortable for multi-proposed use when the aged is at bed area.

3. Need of Warm color for task lighting with low heat are preferably recommended to be not annoyed the elder readers.

4. Providing a special indirect light around under the bed or the point which risk being accident in the night time. There also have sharing in-between space where continue to the bed area.

Considering task planes for seniors related to activity in the bed space.

Prior to research processing, the consideration in working task planes for seniors related on their frequent visual activities. The appropriated dimension, level is based on ergonomic human factors (Molly Follette Story, 2011) Its outcome can be divided into main 3 planes of illuminance (Figure 4):

1. The level from the finished floor is not higher than 30 cm for moving activity (no.1).

2. The level at 60-90 cm from the finish floor considered in working (reading or doing some activities on the chair) (No. 2).

3. The level of sight on the vertical planes such the mirror or dressing (No.3).

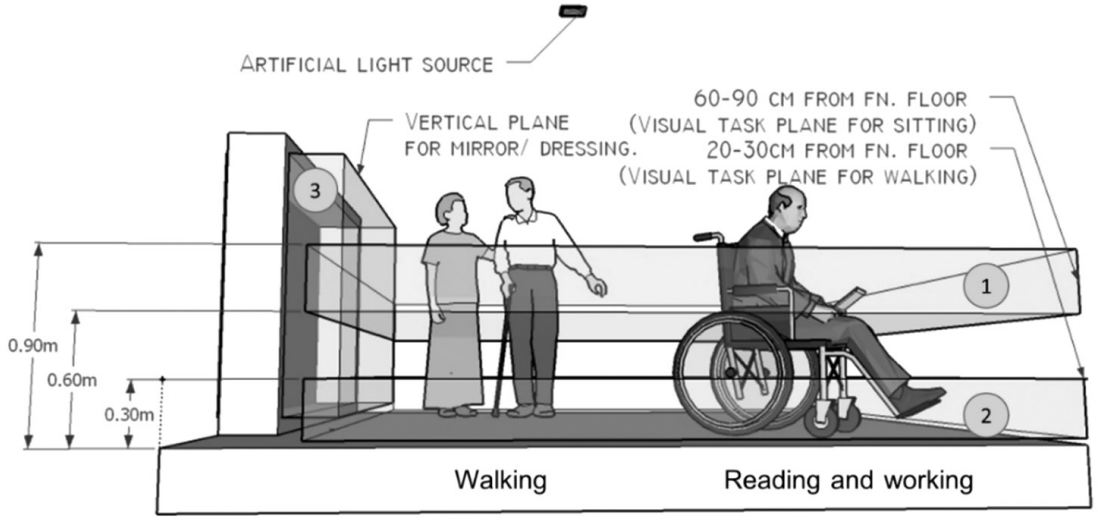

Figure 4 Summary of the consideration task planes for seniors related to activity. (Siriwan, 2015)

The process of work

To acquire the scientific values of illuminance (lux) which can analysis and calculation, The data collection method is proceeded is divided by 2 ways:

1. The first way is the combined method of the spot and area measurement (IES, 1981) on site. The scene setting into the dark, by eliminating natural light and turning on only the artificial light. Then a digital light meter (LX-73) is used as a measuring instrument. The method of measurement is set in every 1x1 square meters along the space and start to measure on the finished level (+ 15 centimeters from floor for a walking plane and +75 centimeters for a reading or working plane). Then the digit values is plot on the plan drawing.

2. Simultaneously, it uses the illuminating simulation from the real lighting situation in both a position, a type of lamps and the space environment. The lighting software tools is to complement and contribute to the research process, this study concentrates on the result which present the numerical value and the margin of illuminance. As the requirement, DIALux Evo, the software is based radiosity lighting calculation software. The output from DIALux Evo is presented in false color diagrams and boundary of values illuminance, this software is issued the output in calculation table, diagrams, perspective rendering and specification of light bulbs used in the simulation (Bickford, 2008)

By comparison, both methods present the different numerical values. It founds that the values from the on-site measurement is lower than the simulation method, approximately the 10-20 percent. In practical, the illuminate evenness as used is lower than the specification mentioned the product label. So the suitable method to obtain the close data is to be collected from both LX-73 plot and regenerating illuminating simulation from the Lighting software (Dialux) to improve the quality of lighting.

Result and Discussion

Senior housing unit selected.

Due to various types of senior living unit at the present, the case study selection for this research should set up a criteria to conduct the variables: the role model in the standardization of architectural designs for elders (Jarutat. 2013.), the good location, the amount of beds in a room, and healthfulness of residents in a unit. From the survey

in Bangkok and its perimeter, Sawankanives Project was selected a qualified paradigm (JLL. 2017)

Sawankanives is the condominium unit for seniors' living, located on Bang Pu, Samutprakarn, Thailand. The area of the bed zone contains 14.4 square meters (fig 5). The existing lighting fixture in the bed area is consisted of 3 down lights above 2.65 meters from the finished floor level and a wall mount light between two beds (Figure 6). On site preparation, the natural light was all blocked by black material sheet. The study can achieve to accurate values of illumination of existing artificial lighting.

1.Rendering perspective

2.As-built perspective

Figure 5 The view of the bed area in a senior unit.
(The Thai Red Cross Society, 2014)

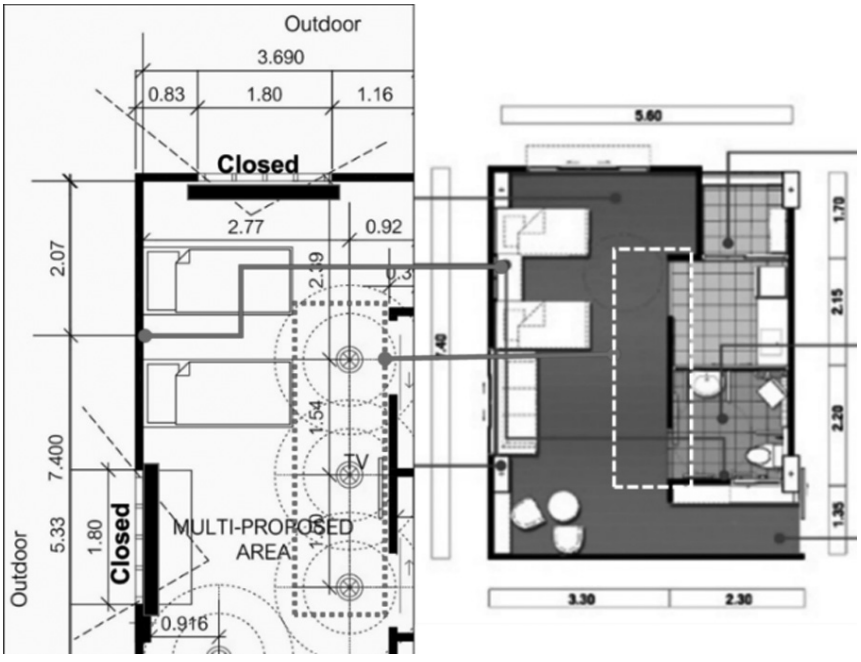

Figure 6 Plan show the lighting position in the bed area. (Siriwan, 2015)

Table 2 Summary of the position of lighting fixtures in the bed areas.(Siriwan. 2015.)

Position	Light bulb	Units	Distance from finished floor level (m)
Bed area	Down light 18w 1100 lumen w/acrylic filter, Warm white	3	2.65
	Wall-mounted light	1	1.50

Refer to Figure 7 and Table 3, it showed the values of illuminance that is resulted from the area measurement with the existing down light fixture in a bed area. The data implied that only the values of illuminance from the existing ambient artificial lighting (75-90 luxs). It was adequate for night light, close to floor monitoring lights for care staff at night, close to floor, but it was not met the seniors' lighting level requirement in reading or working light on the bed level/reading level. (Table 1).

The outputs from both the spot measurement (Figure 7) and the lighting simulation (Figure 8) were compared and analyzed to consider to the reference before improvement, it found that both way issued the conforming ranges of the values. It was summarized that the acquired values of illuminance were divided in 3 color zones: green (100-200 luxs), blue (75-100 luxs) and dark blue (0-50 lux) (Figure 8) (Figure 9).

Following Figure 7, it implied that the value of illuminance in most bed area is between approximately 31 to 76 luxs at the floor plane, except the area connect to walking way next to the another room (Figure 8). In this area needed the light to see the way for move from a bed to another area. Likewise, at the plane on top surface of the bed tip next to the walking path, its value was between 100-143 luxs (in the green zone). The value on the surface of the bed mattress was faded to the dark blue zone, which it was between 0-50 luxs, to support sleeping activities.

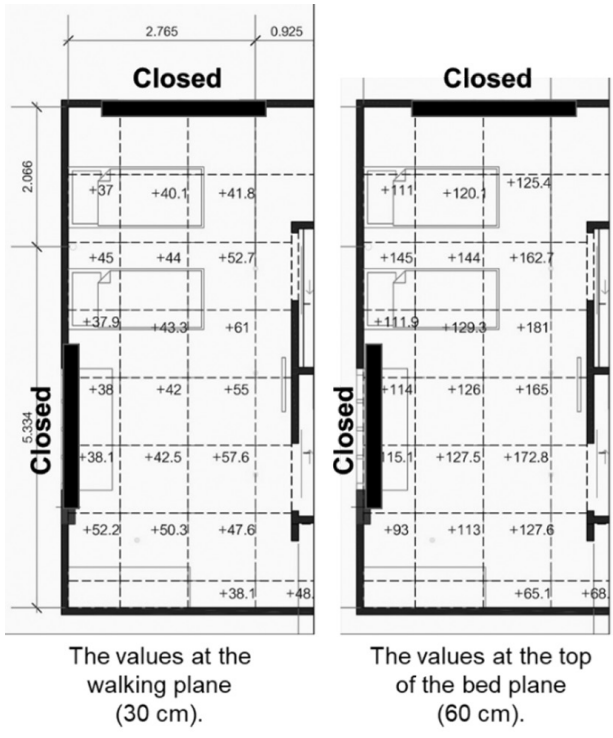

Figure 7 The Plan diagrams show values of illuminance from the spot measurement. (Siriwan, 2015)

Table 3 Summary of the artificial lighting in multipurpose area (the ambient light)

AREA	MAX. VALUE OF ILLUMINANCE (LUX)	MIN. VALUE OF ILLUMINANCE (LUX)	LIGHT COLOR/ COLOR TEMPERATURE	DISTANCE TO WORKING PLANE
B WATCHING TV/ LIVING AREA	200	138	Warm white /2700K	2.65
C BED AREA	75	90	Warm white /2700K	2.65

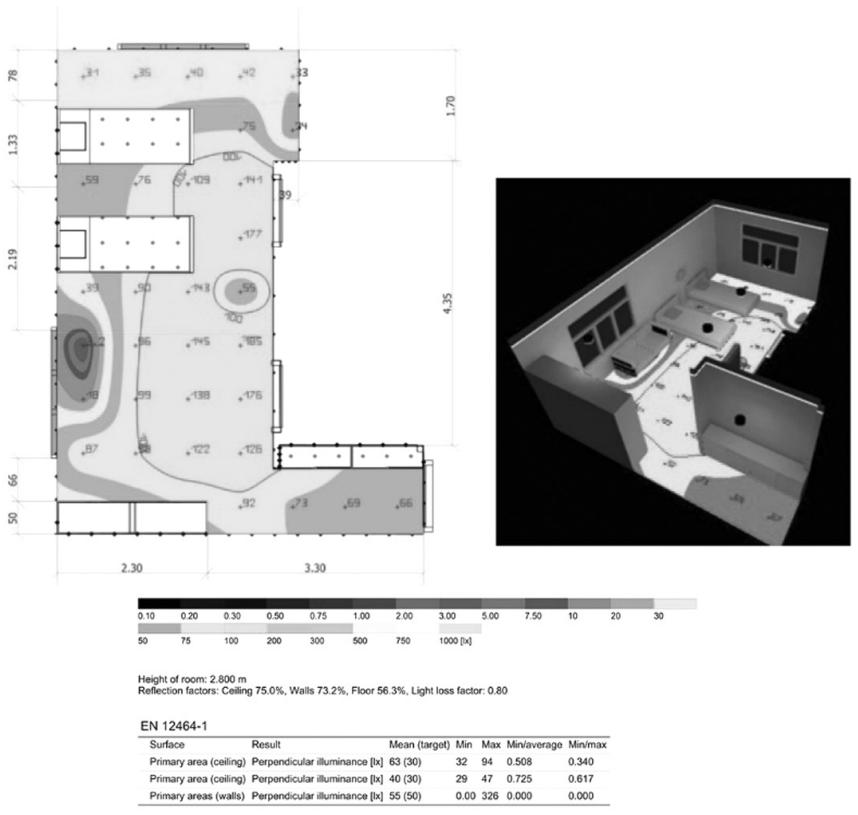

Figure 8 The model of the value of illuminance (luxs) from the lighting simulation. (Siriwan, 2015)

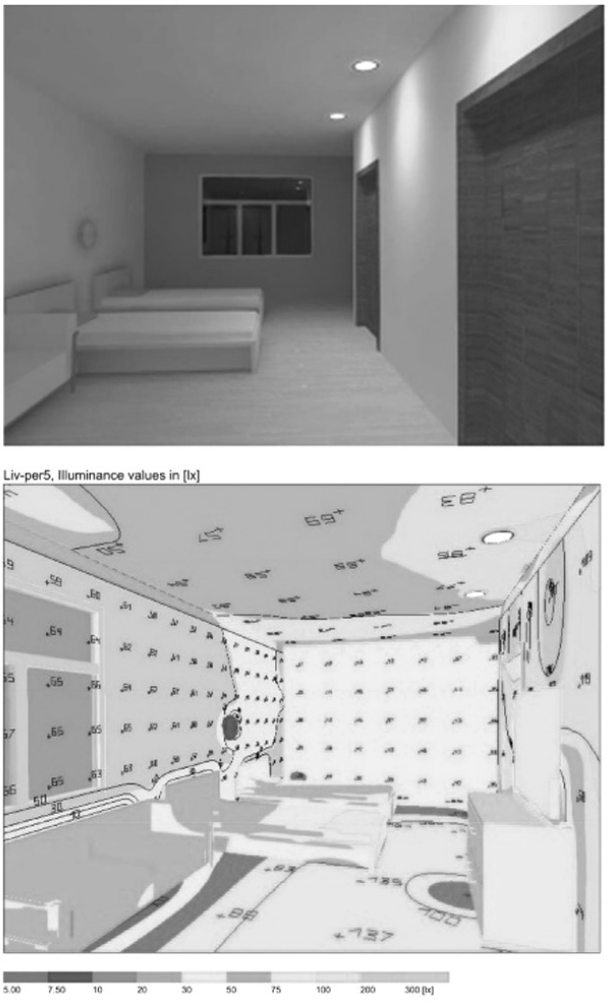

Figure 9 The model of the value of illuminance (luxs) in the bed area.
(Siriwan, 2015)

Discussion

Bed area lighting concept and possible improvement

The development principles of artificial lighting in the bed area are to response all possible activities in one place in 24-hour. The lighting in the space is finely combined among ambient, task and accent types. (Figure 10). From the interview 8 people in 4 living units about the comfort of lighting in their bed area, it found that 5 older adults need special lights for their private activities in night time as the other need to get rest with dim light. Also 3 units, the married couples, need the shared lighting in a bed head position to their couple can see the other and help him in some cases such being sick.

As the results, there have 3 issues is divided for consideration to light for the senior bed area They are consisted of selecting types of lighting, directing to the task area/point(s), and the appropriated values of illuminance (lux) to the senior residents' vision.

The offered principles for the possible improvement are operated by changing the type of lamps fitted for usages, and adding lighting to reach to suitable illumination in the bed space. Also it can do adjust the existing ambient lights to emotional lights for multi-activities, at the same time, add more task lighting to rise the illuminant quality. In case of the two senior resident who need to sleep in the different period of time, In the conceptual improvement, it should provide the separate lighting for individual to avoid light disturbance (Figure 10).

This can be integrated to upgrade the efficiency of lighting from previous principles and recommended light level (Table 1) (Figure 1) (Figure 2). After considering from above tables and figures, it implies that seniors need different ranges of light level to promote activities. The lamp should be adjusted at the level of illuminance to promote the soft activities in the task area such sleeping or doing silent activities. Seniors need some artificial lighting replace natural lighting position to control senior circadian system as treatment as sleeping.

Table 4 Summary of the illuminance need for activities in a senior bed area. (Siriwan, 2015)

Activity at the bed space	Illuminance need in lux(s)	
	60 years old	80 years old
Sleeping	-	-
Moving (night light for guiding)	50-100	n/a
Reading	300-1076	1614 (in averaged)
Doing Hobbies	807-2152	3228 (in averaged)

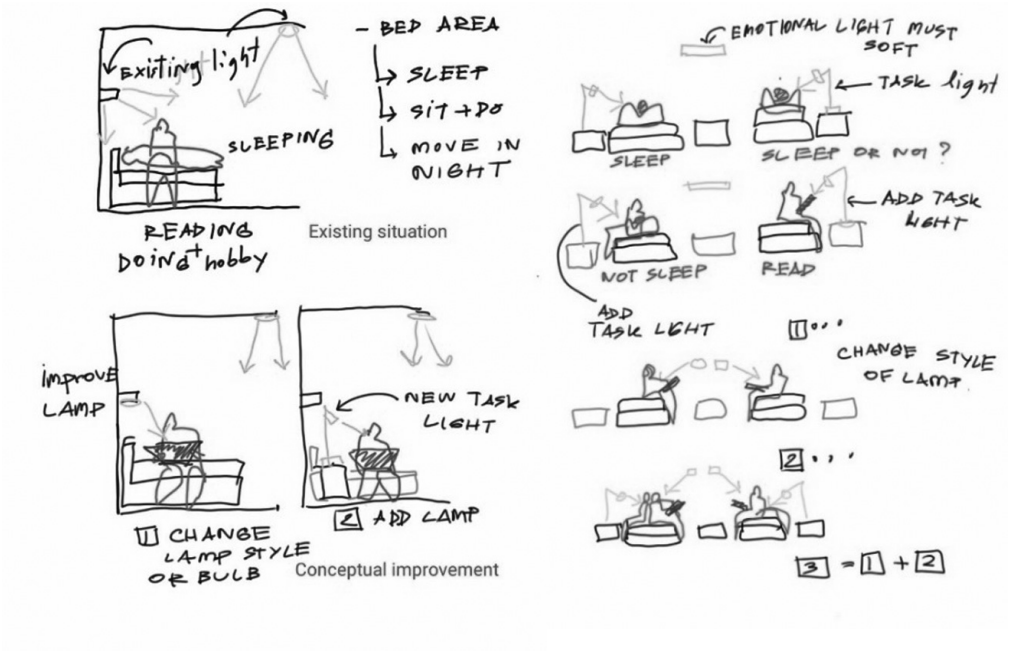

Figure 10 Conceptual improvement and options in artificial lighting. (Siriwan, 2015)

Regenerated modelling to experiment, analysis and outcomes.

According the result of illuminance in the bed area, its value is between 100 to 200 lux, which is adequate for an elder can see and move safely around a bed area (Figure 11). Yet it is deeper investigated in the visual task area at the bed area, it discovers that its lux values do not suffice for the visual heavy activity, for instance, reading a book. It should add task light in a special point which the activity need. The existing lighting bulbs in the bed area from only functional lighting to semi-emotional light is not enough. The value of illuminance is about 86 lux, meanwhile, fixture more task light in a special-needed point. Basically, it may propose a floor lamp or a table lamp, which its task working plane is 70 cm high, illuminate approximately 646 lux. The lamp should be controlled by a dimmer switch (Figure 11)

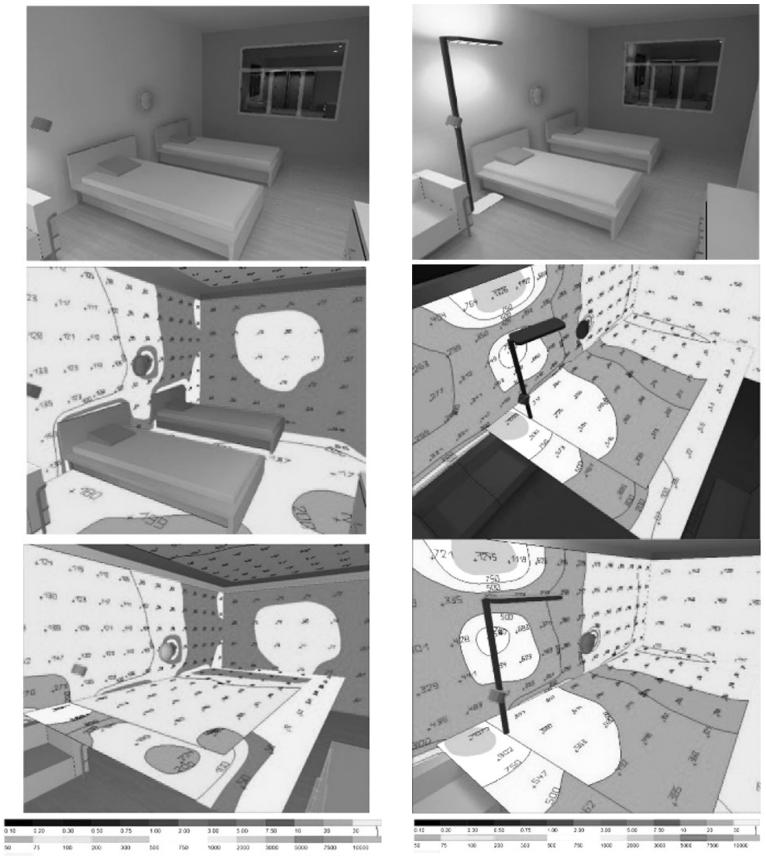

Figure 11 Analysis the value of illuminance (luxs) before and after setting up the lamp. (Siriwan, 2015)

The improvement by increasing the lamp in a task light at the height of 1.90 meters with a 4500 lumens, 36 watts LED bulb is measured the illuminance value between 500-700 luxs. When the lumen of the light bulb is decreased to 4200 lumens, the illuminance will be 563-667 luxs, closing the value needed (Figure 11). In Figure 11 analyzed the value of illuminance (luxs) before and after setting up the lamp. In the experiment, the simulation is divided into 2 situations to response the individual visual task. The first set supports the heavy task being adjustable in the range between 86 to 646 luxs. The way of development is using of adjustable wall mounted lamp at the height of 1.90 meters with a 4200-lumens bulb. It should also provide more lamps with the illuminated value is until 86 luxs for the path around the bed. The following result is the value of illuminance be sufficient, however, recognized separate electrical fixture should be set to be more convenient access. Table 5 summarized the data from conceptual

improvement and its suitable values of illuminance (luxs). It presented in comparison between existing and alternative in lighting principles and its values of illuminance (luxs). The result implied that the values of illuminance (luxs) in the bed area should be higher than another zone in a multipurpose area. This promotes the task lighting for activities from soft activities (relax) to heavy task activities for 60-80 years aged people. (Figure 2)

Table 5 Summary of Possible illuminance in senior housing unit after improvement. (Siriwan, 2015)

Area	Measured illuminance before(lux) at night	Referred combined standard illuminance (lux)	Recommended illuminance (lux)	
			Ambient light	Task light
Multipurpose area	-	322.8	322.8	-
TV and computer zone	138-200	322.8	322.8	-
Bed area	75-90	322.8	385	930

Table 6 Summary of the comparison between existing and alternative principles. (Siriwan, 2015)

Area	Existing Principles	Alternative principles
	Higher levels of light to compensate the restricted light coming and absorbed by elders' eye age-related changes.	Optionally, changing to intensive light color such warm yellow with lower illuminance can compensate the restrict light as well.
	Use of Low intensity as bright light for light therapy	-
	Warm tone light such yellow light can therapy elder sight by helping them distinguish objects and space around them to reduce accident and depression.	-
	Bright green light and bright white light can treat depression in older people.	No survey
	Light fixture should not flicker or hum, light in a room must clear.	-

Area	Existing Principles	Alternative principles
Bed area	Use of daylight and ambient light to alleviate eyes fatigue, help elders read or watching easier.	No survey.
	Task lighting in bedroom should be adjustable to be more comfortable to read on bed.	The combination of lighting from ambient, task and accent lighting fixture is alternatively use to response overall possible activities in one place a day. Changing lamp style or add lamp is possibly practical solution. In case of the twin bed area (Figure 10, Figure 11), there are Options in lighting improvement: 1. Turn the existing light to emotional light for universal activities or change style of lamp to 2 lamps with switch themselves. 2. Separate task lighting for individual to avoid annoyance each other. 3. Combination of application both 1 and 2
	The accessible points of switch are needed.	The accessible points of switch is also depended on bed type such a twin bed or one bed.
	Warm color for task lighting with low heat are preferably recommended to be not annoyed the elder readers.	-
	It should provide a special indirect light around under the bed or the point which risk being accident in the night time.	-

Conclusion

The results from this research are summarized as fine lighting guidelines which offers the extended margin in details improved from existing lighting principles. The alternative principles recommended in additional artificial lighting techniques and the updated values of illuminance (luxs). The outcome is valuable to elders' well-being in the aging society, particularly it promotes the artificial lighting for seniors' comfortable vision to facilitate doing activities in their bed space. It helps the elders see clearly without weariness in their bed spaces all 24 hours. Also the alternative principles offer the guideline for not only aged-friendly and convenient, but respectful of user privacy in the space for multi aged users supporting the Thai aging society in the nearly future.

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