The Impact of Indoor Lighting on Students' Learning Performance in Learning Environments: A knowledge internalization perspective

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Abstract

The purpose of this study is to identify the influence of indoor lighting on students' learning performance within learning environments from knowledge internalization perspective. This study is a comprehensive review of literatures base on the influence of indoor lighting on people's productivity and performance especially students' learning performance. The result that comes from this study shows that it is essential to improve lighting in learning environments to enhance students' learning performance and also motivate them to learn more. In this study the researchers utilized Pulay (2010) survey and measured the influence of lighting on students' learning performance. Utilizing survey data collected from 150 students from Alpha course in Malaysia. This study found significant impact between lighting quality and students' learning performance this finding is also supported by interview from two experts.

Keywords: students' learning performance, learning environments, lighting quality, students' motivation

1. Introduction

Many elements have affected into environments, and the environments have directly affected people. Well designed environments make people happy and energize and vice versa. These elements start with building structure and shape, and complete with color, light, outside viewing and furnish. Sometimes, the influence of light in the environment is much more than other elements. Understanding the relationship between light and the environment can help designers or architects to improve interior designs for better performance (Oneworkpalce, 1999).

In this study, the researchers have focused on the influence of light (indoor lighting) on students' learning performance. Also this study observes this process from the knowledge internalization perspective which refers to SECI model of knowledge conversion that came from Professor Ikujiro Nonaka and his colleague (Gourlay, 2003). The researchers mention the SECI model in this study because it is important to manage knowledge for a variety of reasons, then having a good model to support this process also is equally significant. In 1998 Nonaka and Konno introduced the "Japanese theory of *Ba*", which related to the physical, relational and spiritual factors of 'place', or possibly 'context'. The SECI model (figure 1) shows the process of conversion, creation and transition of information and knowledge from tacit to explicit and explicit to tacit. In fact, the environment and all elements are exist in environment have very critical role and direct impact to these transition and creation of knowledge (Rice & Rice, 2005).

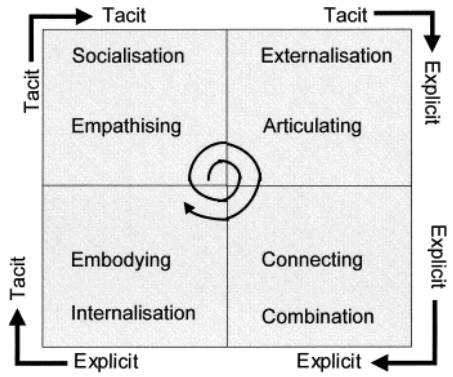

Figure 1, SECI model

Knowledge creation itself is a process of connections and interactions between two types of knowledge. These two types of knowledge are explicit knowledge and tacit knowledge. Nonaka, Toyama and Konno (2000) indicate that there are four types of knowledge conversion. These four are: socialization (tacit to tacit); externalization (tacit to explicit); combination (explicit to explicit); and internalization (explicit to tacit) (Nonaka, Toyama, & Konno, 2000).

In 1998 Nonaka and Konno established a third more challenging theory to the SECI model that called *Ba*, a philosophical construct which rooted in Japanese society. This part relates to the physical and spiritual factors of 'place', or maybe more widely 'context'. Four different concepts of *Ba* are explained in relation to each of the four parts of the SECI model main theory. They come together and make up the 'knowledge spiral' that SECI model is based on (Nonaka, Toyama, & Konno, 2000; Rice & Rice, 2005). According to Rice and Rice (2005) four different concepts of *Ba* are:

1. The first one is the place where individuals can share emotions, experiences, feelings and perceptual models that called "the Originating *Ba"*. It is about physical and face to face experiences are the key to exchange and transfer of tacit knowledge. Professor Ikujiro Nonaka emphasizes that the physical contact and relation is essential in originating *Ba* to make knowledge creation easier through Socialization. It is the beginning and the first step of the knowledge creation process in SECI model.
2. The second one is the place where tacit knowledge is transmitted and documented to explicit that called "the Dialoguing *Ba"*.
3. The third one refers to a virtual space that new technologies help to create new explicit knowledge by recombination of existing explicit knowledge that called "the Systematizing *Ba*".
4. 4. The forth one is a place that explicit knowledge is transformed into tacit knowledge that called "the Exercising *Ba"*.

In 1998 Nonaka and Konno highlighted the cognitive scope and the task specific of tacit knowledge. They also explained the emotional feeling and the spiritual features of knowledge and its positioned space. Knowledge learning and cognition, they highlighted, appears from both straight experience and mental and physical experience. Physical experience will come from the physical environment. Physical environment include all elements within a place such as lighting, heating, texturing, furnishing and so on. These elements are some of environmental features that should consider in environmental design and they also have effect on users' feeling and outcomes. Schools systems or learning environments in general are the most critical environments with many reciprocal actions (Higgins, Hall, Wall, Woolner, & McCaughey, 2005). Basic physical variables in environment like noise, light, color, temperature have effect on learning in learning places. The schools' facilities are an important infrastructure with many technical qualifications that must be correctly addressed to create the most suitable spaces for student learning and teaching. In fact researches indicate that the physical environments influence on students' achievement and behavior (Higgins, Hall, Wall, Woolner, & McCaughey, 2005; Tanner & Langford, 2002). Besides lighting in interior schools design there are many other elements that might influence students' performance. For instance, acoustics, maintenance, cleanliness of the school, color and color pattern, textures of the floors and walls, classrooms flexibility, and safety (Tanner & Langford, 2002).

There is a fact that people work better in places which they feel comfortable there (Oneworkplace, 1999; Monteiro, 2012). Companies can increase job satisfaction by providing a good working environment, and this truly worked in educational places as well. In fact, the well design environment has effect on users' health from physically to mentally (Erwine & Heschong, 2002). Since learning has a special place and role in people's life; providing such conditions to improve this situation need special attention. Today, by the speed of technology growing the facilities for improving educational places are improved as well. Among all environmental elements lighting has a very powerful impact in people's life and health (Oneworkplace, 1999). It also has a very essential impact in people's productivity and performance.

Consistent with Veitch and Newsham (1998) while individuals able to answer all behavioural needs in a position the lighting quality exists there. According to Veitch (2000) as cited by Mahbob, Kamaruzzaman, Salleh, & Sulaiman (2011) this description has the advantage of being measurable, but it only considers the direct results of the bright situations on the individuals. Besides that, architectural and economic considerations, as well as individual well-being must be measured (Figure 2).

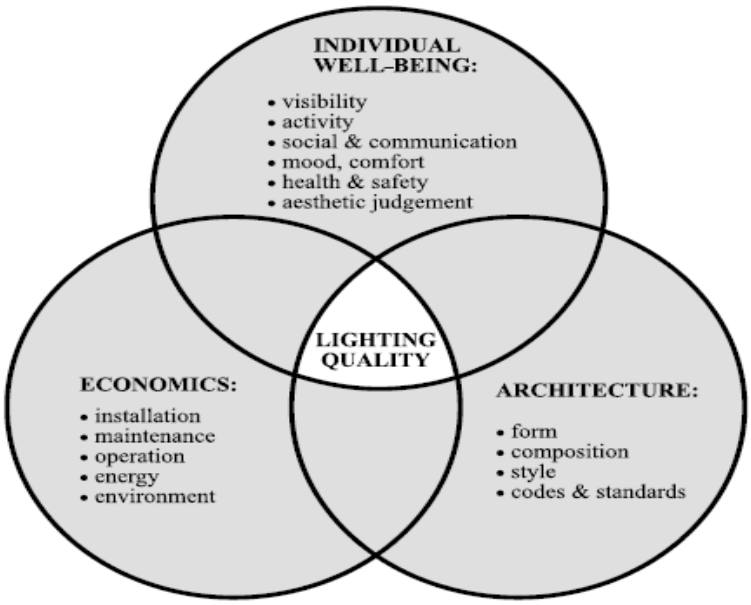

Figure.2 Lighting quality: the integration of individual well-being, architecture, and economics

1.1 Problem statement

The first problem is people have many elements in their environment, but they just take for established some of them. However people just don't think about the quality of lighting. Even while there have been successful improvement in lighting technology, unfortunately much of these results haven't been applied to support people with their current situation in their studies or work environment (Larson, 1998). According to Monteiro (2012) "lighting conditions in the majority of the workplaces are below recommended guidelines and the normalized values ate more representative in workplaces with general and localized lighting." The poor lighting and the lack of attention to improve the lighting facilities or using daylight are critical problems that many organizations and learning environments are faced with (Oneworkplace, 1999; Lyons, 2001). When students have a classroom that have not well control of windows and lighting students' performance is negatively affected (Johnson, 2011).

Designing a learning place is the most critical and important situations that designers face with. But most of the time this importance are rejected. And here the second problem comes out. For instance, in the term of designing a workplace, designers must be aware because, they must design for three different perspectives: staffs and management, users and designer. Rylander (2009) explained that these three perspectives have different meaning, view and idea about the workplace environment.

And they more have different view in terms of the interpretation of the role of office and the process for designing that. For designing learning places, designers must have the same view. However, designing a learning place like school or university is more critical than workplace because of the importance of learning and education in people's life.

Many people spend the majority of their time in the work or learning places. So, good environmental designing in school and universities is a kind of stimuli for students and even teachers to have better performance. The purpose of this study is to discuss how learning environment like schools, universities and colleges must be designed to provide a better atmosphere for learners. In this study, researchers try to express how lighting quality effects students' learning performance. This is important to know light has a significant impact on people's performance in the workplace and classrooms. Good lighting in learning places enhances users' (here students) performance and enhance the overall performance. Evidence indicates that in general, appropriate lighting quality can increase productivity and performance, decrease eyestrain and fatigue, and enhance an organization's opportunity for success (Oneworkplace, 1999; Monteiro, 2012; Johnson, 2011).

1.2 Research model and hypotheses

Figure 3 shows the research model, which hypothesized: the relationship among lighting and students' learning performance. Colour also has a kind of impact on students' learning performance specially while combining whit light. Individual differences (here age and gender) moderate this relationship.

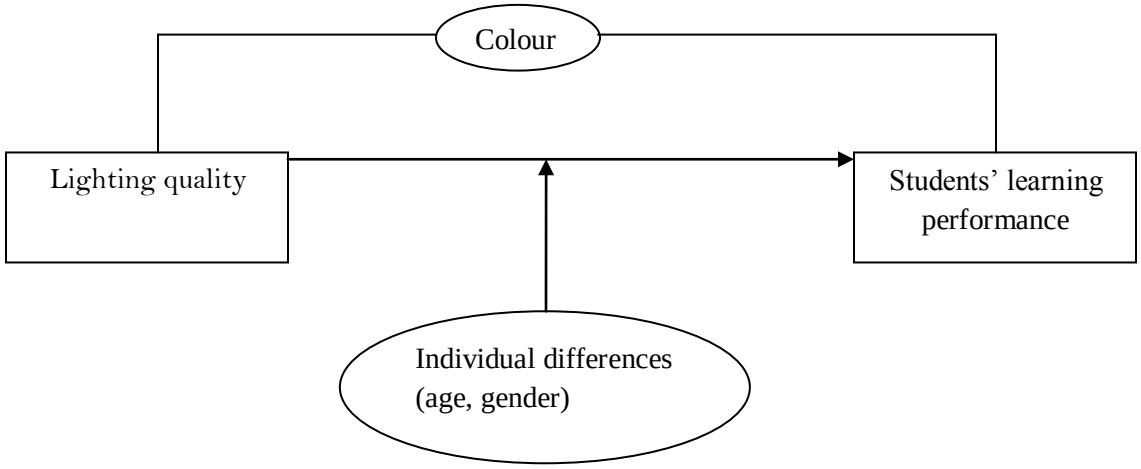

Figure 3: Research frame work base on variables

H1: There is a significant relationship among students' learning performance and the quality of light in classrooms.

Lighting is a fundamental feature of the designing building environment. Good lighting should be comfortable for all building users. With the modern technology designing a lighting system to meet all requirements of an environment is possible (Bright, 2009). Environment illumination is very important for determining the users' well-being and productivity. Illumination is a critical area that needs more attention from educators, administrators, designers and maintenance teams. Illumination is not only about electric light it also consist of direct natural light, indirect natural light, and indirect artificial light and reflected light, as well as the control of all light resources (Fielding, 2006; John & Timothy, 2005; Liberman, 1990; Oneworkpalce, 1999)

Variable light applies a potential advantage in indoor office accommodations with respect to subjective or emotional mood (Hoffmann, Gufler, Griesmancher, Bartenbach, & Canazei, 2008). Controlled daylight and appropriate artificial illumination needs to be carefully addressed in schools as well because lighting is critical to the quality of students performance (John & Timothy, 2005).

In the term of lighting, daylight has an especial place and catches too many focuses. Many studies have even shown access to natural light and fresh air systems can increase health, comfort, and productivity (Gregg & Ander, 2008).

The other critical factor in the term of illumination is the way for controlling it in the learning environment. Insufficient lighting controls can lead to many problems and as well as health problems like eyestrain to serious musculoskeletal injuries, decreased attention span, increased body temperature and, accordingly poor students and teachers performance (John & Timothy, 2005). According to Jago, and Tanner (1999) cited in Knirck (1970) maintained that inappropriate illumination levels "abuse the human eye and have unfortunate physiological consequences".

Veitch (2010) have indicated six categories of human requirements addressed by lighting. These are visibility, task performance, communication and social behavior, health and safety, mood and comfort, aesthetic, and judgments. Good quality of lighting can support human needs; form contributes to conditions in all environments. According to Juslen and Tenner (2005) since changing light is achievable certainly productivity and increase performance via the following mechanism is possible:

1) Visual performance: When people can see the task clear definitely they work and perform that better. Visual performance doesn't have clear deification and importance in all tasks. Some tasks do not need much light in order to be performed well visually.
2) Visual comfort: By remove or decline discomfort glaring the performance will increase because concentration will enhance.
3) Interpersonal relationship: when people can see each other better they can have better communication and more cooperation.

Sine increasing the lighting quality will enhance well-being and motivation among people they will have better performance. Therefore, solving existing lighting problem is very important because it will increase job satisfaction in workplaces and encourage students in learning places for better performance and learn better.

Unsuitable lighting can be the cause of many problems, such as eyestrain to other graves musculoskeletal injuries. Light arriving in human eyes has an essential non-visual biological effect on the human body, impacts human health, well-being and efficiency (Oneworkpalce, 1999). Poor lighting has common exhibit on students or other people as well as: red or bloodshot eyes after reading, be uncomfortable and fidgeting during reading or close work activities, skipping words or lines while reading or writing (Johnson, 2011). Well designed lighting environment can relieve eyes' strain, speed up the recognition of things, and increase visual stability or durability.

According to Veitch and Newsham (1998) the description of lighting quality exists when the environment luminous are appropriate for the needs of the people who will use the space. These requirements are classified in six groups:

1. visual performance;
2. post- visual performance such as eating, reading, walking and all activities;
3. communication and social interaction;
4. mood state such as happiness, performance;
5. aesthetic judgments;
6. safety and health;

For having proof of these six, Jago & Tanner cited in Higgins, et al (2005) "the visual environment affects learner's ability to perceive visual stimuli and affects his/her mental attitude, and thus, performance."(p.20)

2. Illuminating the Learning Environment

Learning places illuminating plays an especially critical role because of the direct relationship that good lighting and students' performance have (Jago & Tanner, 1999). In fact, good lighting is very essential for any spaces that planned for formal media presentation and training, or intended to support teamwork or individual. People need enough and appropriate lighting system for reading or other visual tasks.

Few years ago, before use of electricity became extensive, schools and other learning environment depended completely on uncontrolled natural daylight as the only lighting source. Lighting design moved away from natural light while electricity appears, and classrooms designed with electric lighting sources as their primarily source of light.

On that time the numbers of windows in classrooms area were reduced, and classrooms environments became disconnected from the outside environment. Therefore, because of that disconnection with outside environment classrooms are psychologically suffocate (John & Timothy, 2005).

The visual environment affects a learner's skills to observe visual stimuli and affects his or her mental manner, and then, performance. The fact is if students have motivation in their school's interior environment, they would be more academically successful (Fielding, 2006; Pulay, 2010). The positive effect of lighting on students' learning performance occurs if it designed correctly. According to Pulay (2010) cited in Benya (2001) explained "A well-lit classroom includes glare control, balanced brightness, higher reflectance ratings, and accent on the focal wall." (p.6)

Students must read many different surfaces, like papers or they should look on computer monitors. So they often have to shift their gaze from "heads up" to "heads down," therefore appropriate a high-quality illumination is very critical and important (Pulay, 2010). Lighting in schools environment must be considered as a very vital, fundamental and dynamic element of the whole educational environment (Dunn, 1985). Many elements have directly effect on student performance from physical learning places environment but the influence of light is much more than other elements. According to Jago, and Tanner (1999) the ability of students for think and concentrate on instructions in schools depend on many factors ,and light is one of that factors that strongly influenced in.

H2: Light has a noticeable psychological effect on students' well-begin, this effect will influence students' learning performance

The aim of lighting design is to supply appropriate illuminance, color temperature, and lighting to meet the requirement of the users' vision form physical to psychological. Some people believe that lighting itself has no effect on their performance. Some researchers also argue lighting has no effect on people's mood or performance. But, in the other hand many people believe that lighting in environments has direct effect on their mood and it can change their performance as well. For instance, most of people have spent some of their time in buildings that may feel sick and uncomfortable, and they naturally desire to escape from that uncomfortable environment. That could refer to the poor designing or insufficient lighting quality. There is a kind of stress on people's body that can lead to disease or slow breakdown of biological function. The important point is that the human body wishes to be healthy, and for having a very great physical and mental power it is necessary to have appropriate environment. Each cell in human body is separately able to sense and respond correctly to both positive and negative influences in environments (Rice, 2010). In fact, people have the skills in their bodies to know when a place is good or bad for them. However, sometimes the negative stresses that people experience are slighter and less noticeable or clear to them. As a result, Activation, arousal, and stress are three mental reactions that consider to lighting (Rice, 2010).

Regardless the impact of physical effect of lighting the effect of psychological impact of lighting is stronger. Light sends a visual massage to peoples' mind which can affect people's incentive levels and moods. Light also affects people's biological clock such as sleeping and waking period. In addition, light for propel in their environments works like an alert that can be cause of many changes in people's mood. And any changes in people's moods can be a cause of physical problems or health. This attitude of lighting can be very tangible by changing seasons in the world and the influence of that in all animate stuffs like people, animals, and plants.

Therefore, learning places should design in a way to meet the varying learners' needs of learners form beginning levels till university. In general light and bright colors make people feel joyful and uplifted (Ocvirk, Stinson, Wigg, Bone, & Cayton, 2009). Also, the installation of fluorescent lighting all around the room is one of the attractive options for classrooms at all levels. This action can make the space brighter. By installation all-around high level of illumination, rather than focusing light on desktops, can have suitable psychological plus environment in classrooms for students and teachers working within (John & Timothy, 2005).

H3: Other environmental element such as color has effect on lighting quality and overall students' learning performance.
H4: Individual differences (age and gender) moderate the impact of lighting on students' learning performance.

Environmental designers and psychologists have confirmed that the provision of choices in the physical environment will lead to pleasing consequences for employees, such as better performance and improved mood (Veitch & Gifford, 1996). There are too many elements that may have effect on building design namely: light, color, furnishers, and so on. Goodrinch as cited by Evans (1984) suggests that, "such things as the color, the temperature, the variation of natural light, its soft texture and its ambiences are important, but abandoned factors of lighting."(p.9) This means even the role of other elements in environment are very important and remarkable, but not as important as lighting. Sometimes, too many considering to other elements is the main cause of abandoned attention to the quality of lighting (Evans, 1984). Based on the literature review, the relationship between office design and productivity can be conceptualized and described in figures (4, 5). The figure 4 shows the set of factors which impact on an individual productivity (in the term of increased productivity). And Figure 5 which adopted from Veitch (2001) shows relationships between lighting conditions, individual processes, and individual outcomes. These factors have different impacts on different employees based on the personal differences (e.g. age and gender).

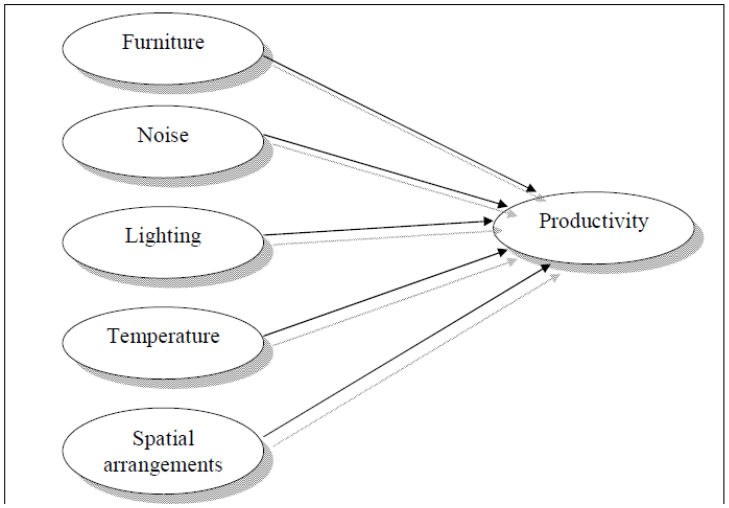

Figure 4- Five indicators of office design such as furniture, noise, temperature, lighting and spatial arrangement are considered for study

The Role of Color: Color is an essential factor in the physical learning environment, and is one of the most important elements in interior design, because it can support light and enhance the impact of lighting on users. Color can make light brighter or darker than normal. Color, is a main designing elements which can be used to create an enriched learning environment while additions to interior form, space, light, and texture (Daggett, Cobble, & Gertel, 2008). Using color in learning environments and classrooms designing will motivate students to learn better. The variety of Color in learning environment reduces tedium and passivity. It also impacts students' performance, as well as teacher and staff efficiency. Hence, "classrooms should incorporate a variety of colors (based on age, gender, subject and activity) to reduce monotony and visually refresh perception." (Daggett et al., 2008) For having better performance in classrooms the right combination of light and color is essential.

Same as light and the influences of that color is the other significant element that directly affects people emotion. This effect can increase or decries people's performance as well. Actually colors play an important role in whole part of people's life and environmental design. Different colors have different effect on people. Warm colors (like red and orange) and cool colors (like blue and green) have different psychological meanings and different outcome into people's feeling. For instance, researches show that workers face with more errors in the white office than in the color offices (Bellizzi, Croweley & Hasty, 1983; Ocvirk, Stinson, Wigg, Bone, & Cayton, 2009). People have different reaction to various colors and lights, and the combination of them. For example, blue interiors for fashion-oriented stores, are associated more favorable evaluations, make them more attractive, than orange interiors. However, the result of effecting lighting after combining with color is different. Applying soft lights with an orange interior generally remove the ill effects of orange (Babin, Hardesty, & Suter, 2003).

According to Halliday (2008) a good artificial lighting strategy has efficient feature. It will usually be valuable and more efficient with combination by good daylight and suitable color and make task easier to do. Where artificial light and daylight are combined, then lamps should be filtered from view to avoid glare and direct contrast between daylight and a uncover lamp. There are some issues to consider for utilizing artificial light include types of lamps, color and luminaries, and problems such as flicker, glare and reflection.

2.1 The Effect of Lighting on different Gender and Age

In 2001 Knez found that females were more sensitive to light than males. Also, he found that they performed in a different way in different kinds of lighting. Results which come from a study by Knez & Kers (2000) different color of the indoor lighting may express different meanings to different genders (Knez & Kers, 2000). In general the effect of indoor lighting on mood and performance of people differentiated by gander, this also makes sense when it comes with age as well.

Human visual systems decline with age, and older eyes permit less light to arrive at the retina than do younger eyes. As people age they become more dependent on their environment to compensate for increasing frailty and sensory loss. Good lighting is a key to creating successful living, working and learning environment, and is necessary to ensure safety, as well as, well-being, health and quality of life. Advanced quality and quantities of suitable and right lighting can help reduce the effects of normal aging vision and increase the abilities of older adults (Myerson, Bichard & Erlich, 2010)

3. Conclusion and The Result Of Data Analysis

For measuring independent and dependent variables, SPSS software is used. This study investigated a regression model. The first testing is related to the relationship between lighting and students' learning performance. That means the relationship between lighting and students' performance to answer the main question of research questions. The result of this regression shows that R-square and adjusted R-square is high. Therefore, they are satisfactory and acceptable. Thus there is a significant relationship between lighting and students' performance. The result of regression indicates that due to the beta here is 0.776 and the p-value is 0.000 that is less than 0.05. Therefore the relationship between lighting and students' performance is acceptable. Also, since p-value is less than 0.05, lighting has significant effect over student's performance.

This statement also is supported by experts' interview. Both experts agree with the importance of lighting in classrooms and the influence of that on students' performance. They argued that lighting quality has direct influence on students' learning performance. According to the experts interview "Good lighting classrooms can motivate students for better learning." In a good lighting classroom students are more relax, do not sleepy, and they have a kind of motivation in that place to learn better. Also "the quality of light in classrooms consider how students concentrate to what they should done or working on." The good learning environments that include the appropriate lighting quality will be a kind of intangible motivation and encouragement for students to learn better. It can lead them to focus on their tasks and working better on subjects. Also according to experts interview adjust lighting in classrooms can increase students' attention and it can increase their performance. Appling light in classrooms or studios base on the subject is very important concept. This means if students have to write something the way that light must apply is different from while they need to look at something in classrooms board. Standing light depend on the subject of the study will essential for all studios and classrooms too.

According to students responding poor lighting in classrooms make them sleepy and they cannot focus on their subject easily. Students also understand by increasing the lighting their performance will be increased. Evidence which came from this study indicated that combination of two types (daylight and artificial light which include both yellow and Fluoresce lighting) of lighting in classrooms can help students to have better lighting quality.

Base on the all results lighting has a very powerful and essential role on students' learning performance on learning places. According to all evidence lighting and the way of applying that in learning places is depend on the subject of study. Lighting control to avoid discomfort and glare in all different types of lighting is very important. Also students feel and act well in a place with a good lighting quality. The best lighting quality comes from the combination of daylight or natural light and artificial light (Erwine & Heschong, 2002).

Designers, teachers and all people who are involved with educational environments must consider about the lighting and controlling that. Physical area in designing is very important and lighting is one of the most important features in physical area in all environments especially in educational and working environments (Knez & Kers, 2000).

According to Jago & Tanner (1999) physical environmental elements such as lighting, heating and acoustics are three aspects that should consider in schools' environment. As well as the overall design of the school, this will surround these aspects. Among these three elements lighting has a special place. Understanding the influences of lighting quality on environment can enhance the learners' performance in educational places. Providing an appropriate lighting quality with the combination of daylight and artificial light in classrooms will motivate students to learn more and it will improve their performance. Therefore, the importance of a suitable visual environment for learning environments deserves careful attention (Jago & Tanner, 1999; Johnson, 2011).

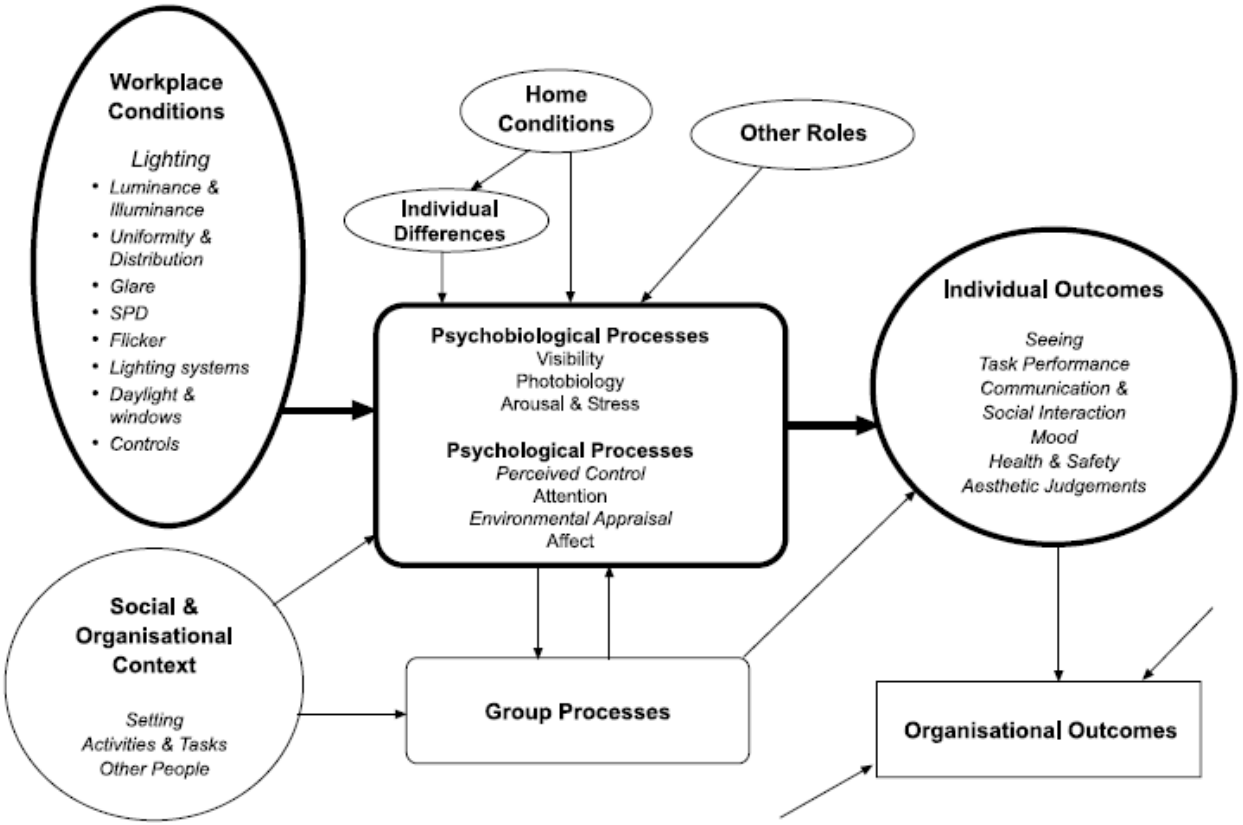

Figure 5, which adopted from Veitch (2001) showing relationships between lighting conditions, individual processes, and individual outcomes.

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