UNIVERSITY OF
FORWARD
THINKING
WESTMINSTER

WestminsterResearch
http://www.westminster.ac.uk/westminsterresearch

Influence on Learning Efficiency from natural light in Educational Environment

Chen, Y., Lau, B., Blyth, A., Schiano-Phan, R. and Yi-Kai, J.

A paper presented at the Passive Low Energy Architecture Conference 2018, Hong Kong, 10 - 12 Dec 2018. .

The WestminsterResearch online digital archive at the University of Westminster aims to make the research output of the University available to a wider audience. Copyright and Moral Rights remain with the authors and/or copyright owners.

Whilst further distribution of specific materials from within this archive is forbidden, you may freely distribute the URL of WestminsterResearch: ((http://westminsterresearch.wmin.ac.uk/).

In case of abuse or copyright appearing without permission e-mail repository@westminster.ac.uk

PLEA 2018 HONG KONG
Smart and Healthy within the 2-degree Limit

Influence on Learning Efficiency from natural light in Educational Environment

A pilot study using EEG Mind Wave Mapping Research Methodology

Chen Yi[1,2], Lau Benson[2], Blyth Alastair[2], Schiano-Phan Rosa[2], Juan Yi-Kai[1]

[1]Department of Architecture, National Taiwan University of Science and Technology, Taiwan,
[2]Faculty of Architecture and Built Environment, University of Westminster, London, United Kingdom

ABSTRACT: This paper presents preliminary research outcomes from applying EEG Mind Wave Mapping methodology for investigating the impacts of learning environment on students' concentration and learning performance under different lighting conditions. During the learning process, whether students remain attentive generally influences their learning efficacy. Literature shows that classroom lighting may be important for pupils' academic performance. However, most of the time, lighting could not be adequately controlled due to the given building envelope design and the spatial layout. The present study explores the influence of different lighting conditions in a conditioned room on architectural students' mind wave when they were engaging in a learning task. Lighting scenarios included naturally lit, artificially lit and hybrid mode set in this room were experimented and the test scores of the learning tasks under these scenarios were compared against mind wave mapping results . The preliminary findings from this study showed that students' performance in a natural daylit and hybrid lit room shows higher concentration than that in the artificially lit room, as a result, the use of natural light in the learning environment is more desirable and this can have significant benefit for reducing energy demands from artificial lighting in educational spaces.
KEYWORDS: Learning Efficacy, Lighting conditions, Electroencephalography (EEG) Mind Wave Mapping, Attention and Relaxation.

1. INTRODUCTION

Nowadays people spend most of their time indoors. In the recent years, a number of studies had been conducted to investigate the relationship between learning efficiency and indoor environmental quality [1]. The findings from these studies indicated the quality of the learning environment has significant impacts on the academic performance.

Many educational spaces experience direct sunlight which normally associated with discomfort glare due to either inappropriate building orientation or solar control, which results in deteriorating visual comfort and in some cases causing health problems. For evaluating the impact of interior environment on learning efficiency, using electroencephalography (EEG) signal sensors to detect electromagnetic mind wave can be used as a more objective metric to corroborate traditional subjective questionnaire-based methods and task-based methods.

This study focuses mainly on develop an alternative and potentially more holistic research methodology which effectively detect, assess and interpret the data collected for the investigation of spatial design and environment comfort for enhancing Learning efficiency in education.

2. NATURAL LIGHT AND LEARING EFFICIENCY

Human beings acquire knowledge in various ways, but mostly from attending school. In the process of learning, attention affects the learning result, and attention is the basis of learning well [2]. Natural light is known to have positive psychological and biological effects on learners. Daylight helps students to retain attention and learn information; and natural light can improve students' feeling, behavior, and concentration [3-4]. During the learning process, whether students remain attentive throughout instruction generally influences their learning efficiency. For creating a healthy and comfortable space for effective learning, internal environmental quality and its effects on learning is an important research subject deserves much attention.

Literature review shows scholars had used EEG signals to evaluate mental exhaustion [5]. However,there are few previous studies employed EEG mind wave mapping technique to investigate the impacts of lighting conditions in learning space on learning efficiency, this study uses EEG signals as the medium to observe architectural students' attentiveness during learning in a conditioned room.

3. METHODOLOGY

Although every individual's attentiveness to the same learning content differs, and their EEG signal fluctuations vary, this study aims to identify the changes in EEG signals during attentive learning under three type of lighting conditions by using convenient and simple methods. In these lit scenes: daylit, artificial lit and hybrid learning environment,

the environmental conditions in terms of the luminous and thermal environment and EEG Mind Wave-related data generated from students' engagement of learning tasks were recorded and analysed at a similar time period.

This study employed highly portable mobile brainwave sensors to gather the mind wave data. The research data was analyzed by using the descriptive statistic. Subjective questionnaire surveying students' perception of the environmental conditions in the room was also undertaken during the experimental process. The ambient temperature, relative humidity, horizontal and vertical illuminance on the worktop were recorded to substantiate the subjective perception of the environmental quality in the room.

3.1 Hypotheses and data analysis

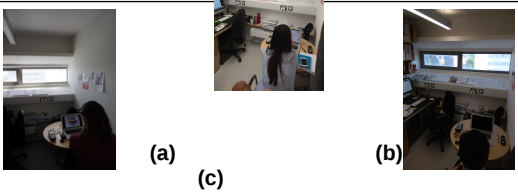
One of the key objectives of this on-going research project is to explore how lighting conditions influence the learning efficiency, attention, and outcomes. The research questions to be addressed are:

- Does interior lighting conditions influence attention?
- Does interior lighting conditions influence learning outcomes?

A group of architectural students from both undergraduate and graduate school participated in this experiment and the Preliminary results is shown in Table 1.The experimental room with different lighting conditions is shown in Figure 1.

Table 1: Data collected from the experiment by using EEG mindwave mapping methodology .

Learning space	Lux Max	Attention Values					Score Average
		0-20	21-40	41-60	61-80	81-100	
Daylighting	476	2%	19 %	36 %	24 %	19 %	93
Artificial light	531	3%	17 %	32 %	37 %	11 %	77
Combine	765	15 %	15 %	35 %	12 %	1%	50



(a) **(c)** **(b)**

Figure 1: Learning spaces: (a) daylighting, (b) artificial light (c) combine. (photos by the author).

4. RESULTS AND DISCUSSION

In all circumstances, the neurons in the human brain are ceaselessly active, emitting small amounts of electromagnetic waves. These electromagnetic waves are used as electroencephalography (EEG) signals. Without training, humans are generally unable to control fluctuations in their EEG signals. Therefore, the use of EEG signals to determine whether students are learning attentively is viable. In the three different learning environments, the mean illuminance ranged from inadequate to excessive were recorded and research data collected shows significant differences between the three group students' attention conditions.

Table 1 shows that the subject in the daylit room produced higher elevated level of attention brainwave values than the artificial lit and the hybrid scenario, indicating daylight enhances attention in the learning process. This finding echoes the collected data on the intuitive perception of the three scenarios. However, could the same observation be observed from conducting a design task which normally does not involved much intensive reading and writing? This will be the next experiment to be conducted in this pilot study.

5. CONCLUSION

This paper presents the preliminary research findings obtained from using electroencephalography (EEG) signal sensors to detect electromagnetic wave patterns which are indicators of learning efficiency in a conditioned room with varied lighting conditions.

The research results indicate natural daylit classrooms can maintain good level of concentration during the learning process without consuming too much energy required for artificial light. The research methodology developed through this pilot project and the findings can help designers and designers gain better understanding of how learning efficiency can be achieved through appropriate classroom design in the future.

ACKNOWLEDGEMENTS

This study was supported by the School of Architecture in National Taiwan University of Science and Technology, Taiwan and University of Westminster, UK

REFERENCES

1. Lee, M. C. and Mui, K. W. and Wong, L. T. and Chan, W. Y. and Lee, E. W. M. and Cheung, C. T, (2012). Student learning performance and indoor environmental quality (IEQ) in air-conditioned university teaching rooms. *Building and Environment, 49: p. 238–244.*
2. Liu, N.H. and Chiang, C.Y. and Chu, H.C. ,(2013). Recognizing the degree of human attention using EEG signals from mobile sensors. *Sensors*,13.8: P. 10273-10286.
3. G.I. Earthman, (2004).Prioritization of 31 criteria for school building adequacy.American Civil Liberties Union Foundation of Maryland, Baltimore, MD, p. 34-42.
4. H. Rittner. and M. Robbin, (2001). Color and light in learning School Planning & Management, 41 (2) : p. 57-58

5. H. Liu. and J. Wang. and C. Zheng. and P. He, (2005). Study on the effect of different frequency bands of EEG signals on mental tasks classification. In *Engineering in Medicine and Biology 27th Annual Conference.* Cambridge, China, September 1-4.