COMPUTER-RELATED EYE PAIN: A CASE STUDY FROM MALAYSIAN PUBLIC (UPM) FOR THE EFFECT OF LIGHTING ON EYE STRAIN AMONG UNIVERSITY STUDENTS

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ABSTRACT: *This paper aims to evaluate the effect of lighting of presentation screen and the workplace on eye and student's performance. Random sampling technique was used as a method for collecting data from students. Data were carefully analysed, and the results from this study illustrate the students 'satisfaction about the lighting in the classrooms. Moreover, the results established a relationship between the eye pain symptoms and lighting in the classroom, as it showed an increasing in a number of students complaining from an eye-pain related problem. The study proved that position of the windows, light resource position and the occurrence of the shadowing on the work surface have led to eye-pain symptoms. On the other hand, the study showed that postgraduate students eyes are strongly affected due to the problem of lighting in the workplace than the undergraduate students. Therefore, specil attentions should be given to the older students comparing to young students. Moreover, extra attention should be given to the natural and artificial lighting sources design and periodic maintenance to achieve good student satisfactions about the classroom's environment while using projection screen. It is advisable that students be offered training courses to increase their awareness about the concept of lighting and computer ergonomic in order to reduce computer- related health problems*

Keywords: lighting; eye-pain; projection screen; workplace; student's performance; classroom's environment

1. INTRODUCTION

The rapid development of digital science and technology has brought the computer to the forefront of teaching aids. Digital projector users have increased immensely in both schools and companies, and more people are now relying on digital projectors in order to brief plans, present papers, demonstrate products, hold meetings and conferences as well as a teaching aid.

Nowadays, a smart classroom usually includes computer at the teaching station, television or audio /video recording system and projection capability to project or send computer signals to a large monitor or each student station. A large projection screen can be watched simultaneously by a large audience in a room [1], whereby lots of information is presented on the display screen instead of papers and other forms. However, spending long hours of work with display screen can cause visual [2], physiological and psychological health problems called Video Display Terminal Syndrome [3]. It has been reported that 50% to 90% users of visual-display terminals complain from eye discomfort [4], due to screen light.

Light is a strong enabler for visual performance that regulates a large variety of bodily processes. The most obvious effect of light on humans is that it enables vision and performance of visual tasks through the eyes. Lighting plays an important role in evoking emotions, and makes an architectural space more aesthetically pleasant. Both natural and artificial lighting affect people's health, mood, wellbeing, and alertness [5]. Lighting is a fundamental feature in designing a study environment. With the advances of modern technology, it is possible to design lighting system that is comfortable for all working environments [6]. Controlled daylight and appropriate artificial illumination needs to be carefully addressed in schools, as lighting affects the quality of student's performance [7]. Several studies have shown that an access to natural light can increase health, comfort and productivity [8, 9]. Illuminating of learning places is essential as it improves student performances [10], and good lighting is essential for any space planned for formal media presentation and training.

Since lighting profoundly impacts numerous levels of human functions, such as vision, its implicit effects on learning and classroom achievement cannot be dismissed. Several studies have addressed how the lighting can enhance students' performance. Visual impairments alone can induce behavioural problems for students that reflect on their level of concentration and motivation in a classroom [11]. Students normally study using either hard copies, such as, papers or soft copies via computer monitors. Thus, students often have to shift their gaze from "heads up" to "heads down,", and therefore an appropriate of high-quality illumination is very critical [12]. The ability of students to stay focus and concentrate on instructions in the school depends on several factors, and light is one of those factors that strongly influence student performance [13].

In this paper, we investigate many factors related to (projection screen lighting & classroom's environment) and their impacts on student's eyes, performances and achievements. This study involves students from different faculties of Putra University, where data collection methodology and analysis are discussed in some details in the following sections.

2. Research methodology

216 samples from five faculties across University Putra Malaysia have been used. The research process started by identification the problem, and then drawing the objectives. The main research tool for data collection was the questionnaires, where it has been designed based on literature. To verify the validity of the questionnaire, members of the supervisory committee and also a panel of

expert were consulted. A pilot study of the survey instrument was done to test the acceptability and reliability of the questionnaire. The collected data were coded, and then computed, and analysis was carried out using the Statistical Package of Social Science(SPSS) (Version 22.0). Descriptive statistics (frequency, percentage, mean, standard deviation, minimum and maximum) as well as inferential statistics including Chi square test, Pearson's Correlation, and Independent samples t- test were employed for descriptive. Likewise, in order to make sure that data were normally distributed, a normality test was reformed for all measures. Research framework has been hypothesizedthe relationship between lighting and student's learning performance that has been further improved by combining light preferences and individual age and gender.

2.1 Research design

The objective of this study is to examine the strength and direction of relationships between two variables. First variable is the disorders that are related to eye pain. The other variable is the lighting inside the workplace, whether the source of lighting was sun light, or source light inside the place or even the light that is emitted from the p-screen itself.

2.2 Sampling

The samples used in the study comprise undergraduate/ postgraduate students and also a combination of international and Malaysian students. Random sampling technique was used for the study, and a total of 216 samples from five faculties inside the university were collected. Sample size was calculated using G-Power software, which is based on power analysis. G-Power is a free power analysis program that is used to perform several statistical tests. The program handling of the data samples is flexible, easier to understand, more intuitive, and reduce the risk of erroneous applications. Thus, G-Power is likely to become a useful tool for researchers and students of applied statistics [14, 15].

2.3 Measurement and Instrumentation

The main research instrument for data collection was the questionnaires. The measurement scales for this study were chosen based on the literature review and previous studies. Furthermore, some of information has been taken from OSHA (Occupational Safety and Health Administration) standards to design questionnaire as well.

2.4 Questionnaire distribution and data collection

Data collection method is a procedure used to gather useful data related to the purposes and objectives of the research during data collection stage. Questionnaire is one of the methods used in collecting primary data. A list of questions has been distributed among students. The questions in the questionnaire comprises of two forms; open-ended questions and close-ended questions. The close-ended questions offered a set of alternative answers from which the respondents were asked to choose the ones most closely represents their views. On the other hand, the open-ended questions were not followed by any kind of choices; thus, respondents' answers were recorded in full. The respondents were given freedom to answer those questions the way he or she understand those questions. The distributed questionnaire is made up of two sections: - section one has focused on the demographic of the dependents and it includes 14 items. Off these items, are the eye pain disorders, which also comprised of two items. Section two, which contain 13 items, seeks to evaluate the physical parameters and also asks about the satisfaction of the students with p-screen and the lighting inside the workplace.

2.4.1 Detemines the variables which are related with the dependents

The studied variables are divided into two parts. The first part is related to the demographic of dependents, and it includes the gender, nationality, age, and type of eye defects. Each item in the demographic chart is subdivided into correspondent categories and is assigned a distinctive code as shown in Table (1, part I). The second part pertains the purpose of using the projection screen (p-screen) and usage time (Table 1, part II), as there is strong relationship between usage time for the p-screen and the health disorders.

2.4.2 The level of eye- pain

The level determination of eye strain in this section is further divided into two parts. The first part investigates the likelihood of student having eye pain while using the p-screen, and it coded such as, "seldom"=1, "sometimes"=2, "often"=3, "always"=4. The second part is about the movement of the person's eyes, whether it moves properly or not, and is coded as "yes"=0, "no"=1.

Table 1. Questioners sample distributed among student. Part (I) is related to the demographic of dependants. Part (II) is about the purpose use of p-screen and duration time.

Part I (demographic of the dependents)				
Gender	**Male**		**Female**	
Codes	**1**		**2**	
Nationality	**Malaysian**	**Chinese**	**Indian**	**Foreigners**
Codes	**1**	**2**	**3**	**4**
Age	**20-30**	**30-40**	**> 40**	
Codes	**1**	**2**	**3**	
Eye defects	**Non**	**With spectacles**	**Colour blind**	**Astigmatism**
Codes	**1**	**2**	**3**	**4**

Part II (purpose of projection screen using and usage time)											
Purpose of using	**Reading (R)**	**Surfing internet (S)**	**Typing (T)**	**Mousing (M)**	**R & S**	**R & T**	**R & M**	**R,S & T**	**R,S &M**	**R,T & M**	**R,S,T & M**
Codes	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
If there is break time each 2 hours	**Yes**				**No**						
Codes	**0**				**1**						
Break time long	**≥ 10 seconds**				**< 10 seconds**						
Codes	**1**				**2**						

2.4.3 Lighting

In this section, we evaluate the physical parameters related to lighting, student satisfaction with regards to the lighting of p-screen and the lighting inside the workplace. Lighting in this section is divided into four categories as shown in Table (2), and each category contains correspondent questioners. The first category is related to the screen, while the second category is about the lighting sources inside the workplace and the windows. The third category pertains the nature of the lighting surrounding the p-screen, while the last category is related to the shadows affect the work surface. Again every item in this questionerhas a designated code in order to facilitate data analysis

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Table 2. The lighting evaluation categories.

Category 1 (Screen)				
Does p-screen clean and free from flickering?			**Yes**	**No**
Codes			**0**	**1**
Does the p-screen situate in a position so that there is sufficient lighting without glare on the p-screen from lights, windows or surfaces?			**Yes**	**No**
Codes			**0**	**1**
Does the p-screen have brightness and contrast controls?			**Yes**	**No**
Codes			**0**	**1**
Does the p-screen have lower light levels than typical office?			**Yes**	**No**
Codes			**1**	**0**
Category 2 (natural and artificial lighting)				
Do there any lighting resource nearby the p-screen or around it?			**Yes**	**No**
Codes			**0**	**1**
Where is the lighting resource position?	**Immediately above**	**Behind**	**In front of**	**Beside**
Codes	**0**	**1**	**2**	**3**
Are there windows in the classroom?			**Yes**	**No**
Codes			**0**	**1**
Where is the window position?	**Parallel to screen**	**Behind / in front of**	**Non**	
Codes	**0**	**1**	**2**	
Category 3 (the surrounding area)				
Does the lighting of the p-screen (vertical plane) similar to the lighting of the desk surface (horizontal plane)?			**Yes**	**No**
Codes			**0**	**1**
Is there any difference between the p-screen lighting and the lighting in surrounding area?			**Yes**	**No**
Codes			**0**	**1**
How would you rate the light levels at your workplace?	**Just right**	**Very high**	**Very low**	
Codes	**0**	**1**	**2**	
Category 4 (shadowing affects the work surface)				
Do you need to assume an awkward position to read the monitor properly	**Seldom**	**Sometimes**	**Often**	**Always**

Codes	1	2	3	4
Are you troubled by shadowing on your work surface?	Yes (very)	Yes (sometimes)	No (hardly)	No (not at all)
Codes	3	2	1	0

2.5 Statistical analysis

Collected data were coded, and analysis was carried out using the Statistical Package for Social Science (Version 22.0). Descriptive statistics (frequency, percentage, and mean, standard deviation, minimum and maximum) as well as inferential statistics including Chi square test, Pearson's Correlation, and Independent t- were employed for descriptive and hypothetical testing respectively. Likewise, in order to ensure that data are normally distributed, the normality test was reformed for all measurements.

2.6 Distribution of respondents based on location

3. Table 3: Distribution of respondents based on their location

Class room	Faculty	Frequency		Percentage
		Undergraduate	Postgraduate	
B008	Modern Language & Communications	15	15	12.6
B027	Modern Language & Communications	10	10	9.5
DKVA	Vetrenary faculty	25	25	19.2
BSC1	food science faculty	10	10	9.5
TM	food science faculty	6	6	7.0
BK3	complex block A	9	9	8.9
BSC8	complex block A	5	5	6.3
BKC1	complex block B	5	5	6.3
BK6	engineering faculty	10	10	9.5
DK6	engineering faculty	13	13	11.2

A total of 302 questioner sheets were randomly distributed among students from five faculties, Putra University. 150 questioner sheets were distributed among the undergraduate students, while same number of sheets distributed among the postgraduate students in same faculties. Table (3) shows the distribution of the respondents based on their locations. . However, 53 students refused to participate in the study, and 33 students did not complete the questionnaire form. Therefore, the total number of students participated in the study was 216 students. Table (3) details number of participants responded from different classrooms that are belonged to these five faculties of Putra University.

4. RESULTS

4.1 Relationship between the eye pain and workplace

In regards to the eye- pain questioner, we notice that 19.5% of the undergraduate students, and 21.2% of the postgraduate students complain from eye pain in the classroom while looking at the p-screen. Where the statistical measures ($\chi2$= 82.544, P=0.001) and ($\chi2$= 86.376, P=0.001)for undergraduate and postgraduate students respectively shows a significance difference between frequencies of two levels among students related to complaining of pain. Furthermore, 84.2% of the undergraduate students, and 87% of the postgraduate students in the classroom feel that their eyes do not move properly while looking at the p-screen. The statistical indices ($\chi2$= 100.507, P=0.001) and ($\chi2$= 103.507, P=0.001) for undergraduate and postgraduate students respectively have also indicated that there is a significance difference between frequencies of two levels among students related to their eye movement. In order to evaluate the level of student's eye pain in a classroom, an average of total score of eye pain was compared with a median scale that is considered as a moderate level (eye pain M=2.000). Table (4) shows a result of one sample t-test. The results showed that the average of eye pain were significantly different from the median scale mentioned above. These results confirm that the eye pain has significant effects on the student's performance in the classroom. The results also showed that, the old students are affected more than the young students [16].

Table 4:- Statistical evaluations of a sample for the eye- pain among students in the classroom

	Classroom	Mean	SD	t value	p value	Test value (Median)
Eye pain	Postgraduate	2.4698	1.0885	0.842	0.034	2.000
Eye pain	Undergraduate	2.2450	1.0943	0.986	0.047	2.000

4.2 Satisfaction about the lighting

A survey with regards to student satisfactions about lighting in the classroom has been held by using a questionnaire also. The results indicate that there are significant different responses for most questioners related to lighting, except for a question about availability of windows in the classroom, the statistical measures ($\chi 2$= 0.116, P value= 0.733) shows that there is no significance difference between frequencies. Nevertheless, the survey shows that 50% of the undergraduate students are not comfortable with artificial lighting as only source of lighting in the classrooms. While 53% of the postgraduate students are not comfortable with artificial lighting as only source of lighting in the classrooms.

In regards to the windows position in the classroom, the results show that 47.3% of the students studying while the position of the windows is either in front or behind them (this result was same for postgraduate and undergraduate, because they were performing study task in same classroom). Thus, the results conclude that students are uncomfortable.

4.3 The lighting sources in the workplace

Combined results related lighting position, the p-screen lighting and the windows position in the questionnaire, give an idea about student satisfaction with regards to the lighting resource design. In order to identify which item, affect students most,

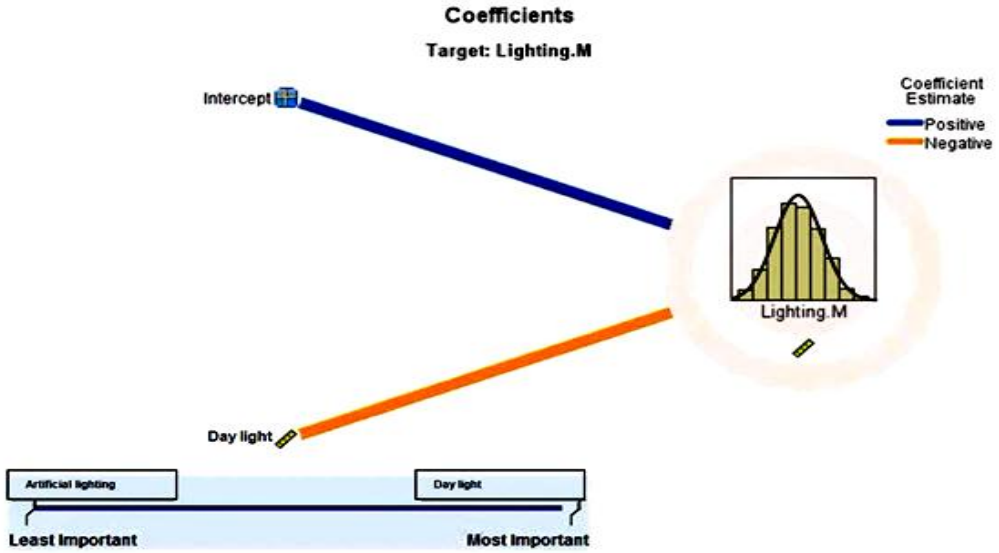

Figure 3. Undergraduate & Postgraduate student's satisfactions about the p-screen lighting, the lighting source position and the windows position.

comparisons among those three items mentioned above were made. Figure (3) shows a clear variance in student's satisfaction about the position of lighting sources, while it is clear from the chart that only 37.71% of the students in the classrooms study while the light resources immediately above of them.

On the other hand, Figure (4) shows a comparison among the lighting sources in the classroom, where the results proved the day light was the most significant lighting source affects student performances in the classroom

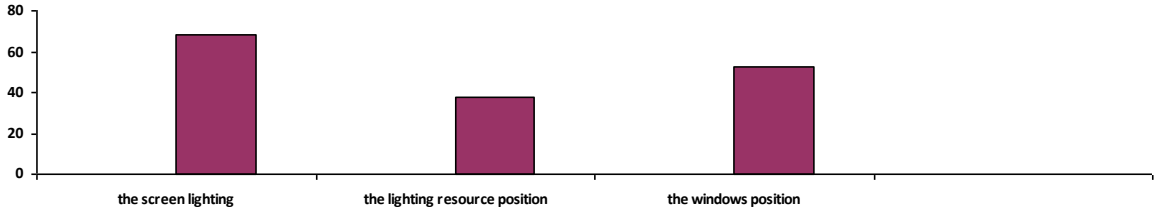

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Figure 4. The most effective lighting source in the classroom

4.4 Total satisfaction of lighting

The total score of satisfaction about lighting was computed prior to data analysis. These new variables were subjected to the normality test, and the results showed they were normally distributed. Thus, one sample t-test was performed to compare the mean consistency scores of college students and physical environment (lighting). The results, in questionnaire, proved significant relationships, in terms of student's satisfaction between (lighting) and the students in the classrooms. In order to determine the student's satisfaction about the lighting in the classroom, the average of total score was compared with the median of scale, as a

moderate level (lighting M= 7.000). Table (5) shows the result of one t-test sample. The results showed the average of lighting is different from the average of scale, which confirmed the level of these variables was less than moderate level. Despite the convergence of values, but the results also confirm that the older students would require more amount of lighting than the young students [17].

Table 5: total satisfaction about the lighting among the students

	Loc2	Mean	SD	t	p	Median
Lighting	Postgraduate	6.842	1.785	-5.805	<0.001	7.000
Lighting	Undergraduate	6.619	1.647	-5.656	<0.001	7.000

4.5 Relationship between the lighting and appearance of eye-pain

Spearman correlations were applied to study the presence of linear relationships between eyes-pain prevalence & lighting and also to determine the significant relationship between lighting sources design and appearance of eye-pain. The correlation helps to clarify how the variables are related in strength and magnitude. The Spearman correlations coefficient r, values ranged from -1 to +1. Table (6) shows the criteria for interpreting strength of relationship between variables

.Table 6: Criteria for interpreting strength of relationship between two variables

		Eyepain.score (undergraduate)	Eyepain.score (postgraduate)
Lighting.M	Pearson Correlation	-.223**	-.292**
	p value	<0.001	<0.001

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

5. DISCUSSION

Several research works [18-20] have studied eye pain symptoms among students in the classroom. Research works indicate that visual and musculoskeletal discomfort, particularly in the neck and shoulders, are occupational health concerns for video display terminal (VDT) users.

Lighting in student study environment is considered an important factor in controlling bodily functions [21, 22], as it has been proved that natural light in addition with artificial lighting are significant factors in student achievements. Students in a classroom normally expos to different natural (daylight) and artificial lighting resources, and lighting every side of a classroom are ideal for student learning and comfort. Thus, in regards to student's satisfaction about the lighting of projection screen, and by a simple comparison between the mean values (6.842, 6.619) for (postgraduate & undergraduate) students respectively, and with median (7.000) values from the survey, it concludes that students in the classrooms are satisfied with the lighting. This conclusion is in agreement with the findings of Wu, *et. al.*, , as the projection screen is obviously farther away from the user than the VDT, hence light coming off the screen will not affect the student performance [23].

Despite of the total satisfaction results among the students about the lighting, yet we still find large number of students complain about eye-pain, where it is likely because the shadow affecting the work surface. This shadowing effect can be attributed to a bad design of classroom with respect to distribution of day light sources. It can be also due to the fact that 62.3% of artificial lighting are projected either in front or behind of the students, which may lead to shadowing the work surface. In figures (5, 6, 7), we show respectively, pictures for the classrooms without windows, windows position rather than parallel to the p-screen and lighting position in some classrooms. The results and figures indicate that students in the classrooms are either facing lighting reflection on the work surface (p-screen) or shadowing on the work surface.

In regards to the relationship between the lighting and the eye pain prevalence, the study results proved that there is a significant relationship between the lighting and the eye pain, due to the negative values of the Pearson correlation. This finding suggest that we can avoid the eye pain by improving the lighting in the workplace, and it is in agreement with the work of Grangaard, and ;Melorose *et. al.*, that light is a strong enabler for visual performance [24, 25].

Moreover, the lack of harmony between the student's answers on the questions related to eyes-pain level on one hand and their satisfaction about the lighting on the other hand, showed that the students have a blur vision about correct use of computers and the lighting in the workplace. It is obvious that even though students are satisfied with lighting, irrespective of the correctness of classroom lighting, students still do not have good understanding about the lighting and computer ergonomics in the workplace.

Figure -5 classrooms without windows inside

Figure -6 classrooms with behind and in front windows

Figure-7 dark places in the classroom because inappropriate artificial lighting distribution

6. CONCLUSION

The purpose of this study is to evaluate the effects of lighting coming off presentation screen and workplace on student eye-pain using p-screen, in order to determine the satisfaction of students in the classrooms with lighting, and to establish relationship between the eye-pain and lighting in the classroom. The results from this study indicate that there is a significant statistical frequency distribution among students in a classroom, and students generally may suffer from eyes pain during the study on p-screen. In the same context, the older students complain from eye pain more than younger students during performing same study tasks on the p-screen

Results for students satisfaction about the lighting indicated that the postgraduate students are affected by improper workplace lighting more than the undergraduate students, although students are totally satisfied with the lighting.

By studying the relationship between the lighting and prevalence of eye-pain, it confirms the eye is substantially affected by problems related to lighting in the workplace. Therefore, improve classroom's lighting may lead to enhance study environment and then will expand student achievements.

Specil attentions should be given to the older students comparing to young students. Moreover, extra attention should be given to the natural and artificial lighting sources design and periodic maintenance to achieve good student satisfactions about the classroom's environment while using projection screen. It is advisable that students be offered training courses to increase their awareness about the concept of lighting and computer ergonomic in order to reduce computer- related health problems.

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