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The Effects of Lighting Intensity on the Productivity of Textile Workers in Surakarta

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Abstract

The textile industries' growth in 2018 have contributed to national economic growth. Enhancing competitiveness through conductive business climate is a strategic step to increase productivity. Surakarta is one of the major cities in Indonesia famous for its textile products. Based on Indonesian Statistic Center, in 2016, the national textile industry productivity declined to 7.65%, directly affecting the productivity of textile industries in Surakarta, including PT IT. The weaving department of PT IT experienced the highest decline in work productivity with physical factor exposure more than Threshold Limit Value (TLV), including lighting intensity. This research aimed to analyze the correlation between the light intensity and worker productivity in 2018. This was a quantitative observational analytic research with cross sectional design in PT IT. From 50 workers in the weaving department, 32 were selected as samples through random sampling method. Light intensity was measured using Lux Meter ANA 999 in 32 measurement points. Work productivity was calculated using Productivity formula= Output (O)/ Input (I). Spearman correlation and SPSS program were used for data analysis. The result showed that there was a significant correlation between light intensity and worker's productivity (p=0.000, r=0.629).

Introduction

One of the manufacturing industry backbone in Indonesia is Textile Product and Textile Industry (TPT). The textile industry remains as the mainstay program of the Indonesian government in the master plan for national development (Susanto, et al, 2017). The textile industry exports has been increasing and is targeted to reach 15 billion USD in 2019 as it becomes a priority sector, mainly because of its chain value and integrated process from upstream to downstream. The textile industry was a rising industry in 2018, promoting growth of industrial sector and contributed significantly to the nation's economy (Kementerian Industri RI, 2018). This sector absorbs significant direct and indirect 2.73 million workforce; therefore we need to improve its competitiveness. Improvement in competitiveness can be achieved by creating a conducive business climate in the form of fiscal incentives, legal assurance, and cutting-edge technology as a strategic step to improve quality, efficiency and productivity (Kementerian Industri RI, 2017).

Surakarta is one of the major cities in Indonesia famous for its textile products. Based on Indonesian Statistic Center in 2016, the national textile industry productivity decreased by 7.65%, affecting the productivity of textile industries in Surakarta, including PT IT. The

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weaving department of PT IT was affected the most, where work productivity was reduced due to exposure to physical factors did not conform to Threshold Limit Value (NAB) such as lighting intensity. The occupational Health and Safety (K3) program in work environment involves factors such as physical, chemistry, biology, ergonomic and psychology. One aspect of the physical factor is lighting (Kementerian Ketenagakerjaan RI, 2018). Lighting affects work productivity, as field studies has shown that productivity was improved by 0 to 7.7% when the required minimum lighting level was met, after taking into account initial condition, tasks, and subjects. In two case studies, it was found that attendance was improved with better lighting (Juslen, 2007).

Women workers in the weaving section of PT IT are required to perform detailed tasks such as ensuring the absence of damaged thread while the weaving process takes place. Workers work for 8 hours to inspect all woven threads. In the initial survey it was found that the intensity of light at PT IT was still below the minimum standard for cotton cloth weaving, which is 300 lux (Kemenaker, 2018). The purpose of this study was to analyze the correlation between lighting and productivity of workers in textile industry.

Method

This is an observational analytic study, utilizing quantitative data, with a cross sectional design. The population in this study were weaving section female workers at PT IT. The samples were 32 respondents who met the inclusion criteria, namely female sex, aged 20-55 years (productive age) with a 3 to 20 years work experience and were picked randomly from a total population of 50 people. Light intensity was measured with Lux Meter ANA 999 tool in 32 measurement points. The measurement point was determined based on general lighting measurements based on SNI 16-7062-2004 measurement of lighting in the workplace by using horizontal intersection of the length and width of the room at a distance of 6 meters for an area of more than 100 square meters. The production room has an area of 30x48 meters. Work productivity was calculated with the formula Productivity = Output (O) / Input (I). Primary data was analyzed using Spearman correlation statistical test in SPSS 17 software.

Result and Discussion

Respondents in the weaving section of PT IT were female, with an average age of 42 years (minimum age of 23 years and maximum age of 50 years). The respondents in the weaving section had an average working experience of 12 years (minimum 3 years and maximum 20 years). The results of light intensity and work productivity measurement in the weaving section of PT IT are shown below in Table 1:

The results show that the average light intensity in the weaving room is 119.38 lux with the lowest intensity at 45.85 lux and highest intensity at 276.90 lux. According to Minister of Labor Regulation 05 in 2018, identification of small and fine items such as weaving light-colored cotton or wool requires light intensity of 300 lux. Maximum lighting at PT IT is still below the required standards of legislation.

The World Health Organization (WHO) define subjective visual disturbance is (ICD-10, H53.1) a form of high-level visual discomfort that occurs after prolonged visual activity, and is characterized by eye fatigue, periorbital pain, blurred vision or headaches. Visual fatigue is caused by visual inefficiency and symptoms that appear in the eye caused by a combination of individual visual anomalies and poor visual

Table 1. Tendency of Lighting Intensity and Work Productivity

Variable	Unit	*Mean*	*Std. Deviation*	*Min*	*Max*
Light Intensity	lux	119.38	65.04	45.85	276.90
Work Productivity	%	0.95	0.96	0.94	0.98

Source: Primary data, 2018

Table 2. Correlation of lighting and work productivity

No.	Variable	Significance (p)	*Correlation Coefficient (r)*
1.	Light intensity and work productivity	<0.000	0.629

Source: Primary Data, 2018

ergonomics (Gangamma and Rajagopala, 2010). Research by Wiyanti and Martiana (2015) on 9 home industries of batik artisans showed that there was a strong correlation between lighting below NAB standard and the incidence of eye fatigue.

Light, in the visual physiology, is essential to process image or non-image with physical and behavior effect. Image formation refers to the process of detecting objects and organisms in the environment to distinguish its physical characteristics, such as size, shape and direction of motion. Non Image can vary from physiological changes such as heart rate and body temperature, or higher functional changes such as cognitive performance and mood (Warthen and Provencio, 2012). The visual system allows humans to process information and perform cognitive tasks. Non-visual effects mediated by retinal ganglion cells are very sensitive to blue light. Neuroimaging studies show that light intensity, wavelength, and duration can modulates the brain's response to cognitive (non-visual) tasks. Light responses are processed through subcortical structures related to alertness area (hypothalamus, brainstem, thalamus) and limbic areas (amygdala and hippocampus), followed by modulation of activities in cortical area which ultimately affects behavior (Vandewalle et al, 2009). Light affects vitality (mental health, health and performance) as evidenced by an experimental study measuring light exposure level to eye using daysimeter in relation to vitality, tension, positive and negative influences through list of activation-deactivation made by Thayer. The results showed that brief exposure to light (5-10 minutes, and 1 hour exposure) is relevant predictors of daily vitality (Smolder et all, 2013).

Data indicate that work productivity was 0.95 in average, with the lowest work productivity of 0.94 and highest productivity of 0.98. Using the formula of Productivity = Output/Input, where output is the daily amount of cotton cloth weaving produced by each worker and input is the number of targets given by the company to each worker, the results were still below the expected productivity rate of 100%.

The results of statistical test comparison between lighting and productivity is shown below in Table2:

Prior to analysis, a normality test was conducted on light intensity and work productivity data. The Shapiro-Wilk test showed that data distribution was not normal (p-value <0.05), therefore we used Spearman correlation test. Table 2 shows the p-value of 0.000 ($p \leq 0.05$), which shows that light intensity has a significant relationship with the work productivity in the weaving section. The correlation coefficient (r) is 0.629, indicating the light intensity has a strong relationship with work productivity. A positive r value indicates that the higher the intensity of lighting, the higher the work productivity, and vice versa. This result is in accordance with the study of Hariyanto et al (2018) which stated that lighting is correlated with work productivity of sewing machine operators with a value of $p = 0.04$ and $r = 0.612$).

Experimental research of light intensity levels at 205 lux, 363 lux, 438 lux, can affect mental productivity or cognitive (Pasmawati and Rachmawati, 2014). Light source such as sunlight and electric lighting has a positive and significant effect on employee performance with a value of $p = 0.000$. Sufficient lighting improve work satisfaction and productivity. Lighting influences 35.4% of the performance of grinding part employees (Irwanto and

Riandadari, 2013).

Ananda and Dinata (2015) study state, that eye fatigue on short sight work is caused by prolonged accommodation in ciliary and extra ocular muscles with light intensity as determining factor on its severity. Light intensity assessment is carried out by comparing the intensity of standards lighting with those that did not meet requirement connected to subjective complaints of eye fatigue, and the result show a relationship between the intensity of lighting and eye fatigue with p-value= 0.007. Dim light or lighting below standard will cause eye fatigue, eye strain and will lead to headaches and irritation, that will decrease productivity (Benedetto et all, 2014). Benedetto's (2014) study shows that exposure to lower levels of light can lead to a decrease in alertness and performance; when measurements of reaction time was carried out, the results showed that respondents in low environmental lighting conditions exhibited a slower response time. This confirms that low lighting exposure can reduce performance. Widowati's (2009) study on the eye fatigue of operators of the Weaving V denim machine shows that there is an effect of light intensity on eye fatigue.

Actions that must be taken to improve the workplace condition are addition of ventilation for natural light source and addition of personal lighting on the spinning machine with a minimum light level of 300 lux. Improving light source to meet the required standard will reduce eye fatigue, an increase in lighting level by 1 lux reduced eye fatigue among respondents by 1,782 milliseconds (Widowati, 2009). Lighting intensity can be improved by designing a transparent roof directly above the working area, lighting modification, addition of artificial/natural ventilation holes on the wall, and painting walls with better reflective color such as ivory yellow that can reflect 60-65% of other light source (Setyawan, 2015). Productivity increase by 18.28% with addition of a white 45 watt fluorescent bulb, caused by white light's reflective property that is more easily sensed compared to other colors. Lamp height of 160 cm will be suitable for average Indonesian female employees with an average height of 150-160 cm (Primadi et al., 2016)

In addition, recent laboratory studies have shown that exposure to white light at higher intensity provide beneficial effects on alertness and vitality during day work, even without sleep and less light source (Smolders et al., 2012). Setting a sufficient light level with a combination of artificial and natural light can create an optimal level of vision and productivity. Lighting is related to productivity (p-value = 0,000) with correlation strength r = 0,720 (Hameed, 2009).

Conclusions

Lighting intensity in workplace has a significant relationship with worker productivity. The better the lighting, the higher the productivity. Weaving section workers at PT IT are workers with precision jobs that are susceptible to the quality and intensity of lighting. However, the lighting intensity in the workplace is still below the minimum lighting standard according to Regulation of Minister of Manpower No. 5 of 2018. Control measures must to be taken through addition of general lighting and personal workspace lighting to a minimum of 300 lux for each room, and more ventilation for natural light source such as sun, vents and lamps maintenance that are covered by cotton dust. Providing workspace with appropriate light source can improve worker productivity and subsequently the industry's competitiveness.

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