APPLYING BASIC ERGONOMIC PRINCIPLES IMPROVES THE QUALITY OF TEACHING-LEARNING ENVIRONMENT IN THE JUNIOR SECONDARY SCHOOL

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ABSTRACT

This study was conducted at the relatively young public junior secondary school at the district of Abiansemal and Administrative Region of Badung (SMPN-3) now aspiring to obtain national accreditation. In this context, the need was felt for improving the teaching-learning environment particularly in the school's classrooms which might be conducive to maximizing the educational input and student performance. We studied the impacts of applying basic ergonomic principles to the design of some physical facilities (including redesign of the tables and chairs) in the classroom aiming to remediate present perceived deficiencies. Our samples were selected by using the multistage simple random sampling technique; and a total of 81 subjects consisting of 43 male and 38 female, volunteer students were recruited. The statistical methods used include descriptive statistics, analysis of normality and comparability.

Our findings implied that interior ergonomic design intervention has led to the following outcomes: enhancing the student performance by decreasing eye strain by 44.76%; musculoskeletal complaints by 50.98%; and boredom by 14.17%. The beneficial outcomes of our intervention appeared to be obvious.

Key words: ergonomics, intervention, interior design, student's perceptions and performance, educational environment

I. INTRODUCTION

Qualified human resources (HR) is an essential factor for developing the community growth and prosperity of one nation. Qualified of HR can be created by school with quality, because is it has a superficial quality of the teaching-learning process. The National Education Ministry of Republic of Indonesia (Kemdiknas RI), has been implemented an accreditation program and learning obliged (Wajar) of 9 years for improving the quality of education and HR in Indonesia. SMPN-3 Abiansemal Badung should be successed Wajar of 9 years, so every 43 students was compulsion learned in the classrom with a capacity of 32 people. Floor area ratio to become 1.52m²/student than it should at least 2.00m²/student. Teaching-learning activities had carried out in the morning and afternoon, so it is proposal to get the SSN accreditation has not yet approved by Kemdiknas RI (Ardana, 2010).

Peoples still hoped, SMPN-3 Abiansemal Badung expected to be recognized as a quality school although not yet accredited as a SSN. One of the distinctive criteria of a school with quality is that its students have good achievement and competencies as a result through the quality of teaching-learning activities in the classroom. Students' performance and the quality of facilities arrangement in the classroom, as partly as important factors in achieving the overall quality of the teaching and learning activities in the classroom (Marmai, 2001; Darmawan, 2006). Ergonomic analysis should be carried out for the purpose of increasing the students' performance which could be recognized as the decrease of eye strain, musculoskeletal complaints, and students' boredom. Concurrently, interior design analysis is also needed in order to enhance the quality of arrangement of teaching-learning facilities so that teaching-learning activities are fun and even satisfying. In order to really achieve improvment of the students' performance at SMPN-3 Abiansemal Badung, it is important that interior ergo-design of teaching-learning process should be applied right away at that school. This application, it is categorizes as a partly of currative ergonomics principal (Adiputra, 2000).

Various study on ergonomics in teaching-learning process, has succeeded to reduce of 54.03% musculoskeletal complaints and increase the average value from 6.5 through 7.0 (Sutajaya, 2004). The teaching-learning process in ergonomic, in order to improve learning outcomes from the mean value of 58.71 in the first cycle through 62.06 in the second cycle or 5.7% (Sutjana et al., 2004). Lighting and teaching-learning process in ergonomic was also able to increase the speed of work by 70.46%, 56.36% accuracy of work and working constancy of 90.95% (Partadjaja, 2004). Redesign of table and chair to reduce fatigue 73.76%, 99.88% musculoskeletal complaints and boredom 26.40% and 65.81% increase learning motivation in addition to learning achievement of 33.70% (Wijana, 2008). Therefore, a study is imperative in order to be able to tests the hypothesis that application of interior ergo-design of teaching-learning process at SMPN-3 Abiansemal Badung would improve the students' performance as could be pointed out as a decrease in eye strain, musculoskeletal complaints and boredom of students' of SMPN-3 Abiansemal Badung.

II. MATERIALS AND METHODS

2.1 Materials

The subjects were 81 male and female volunteer students' of SMPN-3 Abiansemal Badung, aged between 12-14 years, all with healthy physical condition. The class begin on 07.30-12.40, Monday through Friday. The subjects of teaching-learning process will be changed every 40-80 minutes, and on 10.10-10.40 is a break time and some of students will be walked to the canteen and others sitting in the classroom or even at some place of school yard.

Research was conducted at two of interior design at SMPN-3 Abiansemal Badung, that is called: 1) Old interior design (no ergonomics intervention); and 2) Interior ergo-desain (with ergonomics intervention). Figures 1-4 shows a difference of the interior condition, and figure 5-6 shows a difference of chair and table of the two of interior design that its mean.

Fig. 1. The arrangement of front wall in the classroom of old interior design

Fig. 2. The arrangement of front wall in the classroom of interior ergo-desain

Fig. 3. Design of ceiling of old interior design

Fig. 4. Design of translucent ceiling of interior ergo-design

2.2 Methods

Sample were selected by multistage simple random sampling technic, began from determination of the number of students in one group of teaching-learning process by voting through found the status of group 1 and group 2 . Samples follow this study after informed consent filled, and has approval by Udayana University Ethical Commission. This study was carried out using

treatment by subjects design with two-period cross-over design, lasted 5 days (Monday-Friday) for each period. In first period, group 1 learning on the old interior design while group 2 learning on the interior ergo-design. In second period, a reverse position was applied after a 16 day wash-out period was made for adaptation as well with the new facilities.

Fig. 5. Design of table and chair of the old interior design

Fig. 6. Design of table and chair of interior ergo-design

Data were collected by 5 rating scale, on 07.10 and 10.40 (pre test) and on 10.00 and 12.30 (post test) using questionnaires of eye strain, Nordic Body Map, and boredom. 1-S K-S test was done to assess normality of data and deskriptive analysis, and t-paired test was applied for comparative analysis consists of period effect, carry-over effect and treatment effect with confidance level of 95% ($\alpha = 0{,}05$).

III. RESULTS

3.1 Environmental Condition

Results of normality test by 1-S K-S on environmental condition, data obtained in order normal distribution. Furthermore parametric analysis by t-paired test was applied, the results are presented in Table 1. That results shows the intensity of light, dry and wet temperature, relative humidity and air movement on the old interior design and interior ergo-design was significantly different ($p<0.05$). While the intensity of sound, no significantly different ($p>0.05$). Then it can be assumed that the majority of different environmental conditions were exposed to subjects, thus affecting efforts to increase students' performance in order overall to achieve quality of teaching and learning activities in the classroom.

Table 1. Analysis Data on Environmental Conditions

No.	Variables	Old Interior Design		Interior Ergo-Design		*t*	*p*
		Mean	SD	Mean	SD		
1.	Lighting intensity (*lux*)	199.58	22.75	365.68	34.48	-21.31	0.001
2.	Dry temperature (ºC)	28.12	0.97	27.67	1.07	3.94	0.001
3.	Wet temperature (ºC)	25.70	0.86	22.79	0.85	33.54	0.003
4.	Relative humidity (%)	82.06	1.17	66.03	1.02	49.62	0.002
5.	Air movement (m/d)	0.13	0.08	0.20	0.08	-9.22	0.001
6.	Sound intensity (*dB*)	55.06	1.50	55.04	1.51	1.23	0.231

SD = Standard Deviation

3.2 Subjects Characteristics

The subjects of this study were 43 male and 38 female of student, 41 students as a grade VIII-A and 40 students as a grade VIII-B. Two types of treatments were done, one of them is learning on the old interior design and the other one is learning on the interior ergo-design in turn. Subject characteristics of this study were consisted of: age, body weight, body height, right and left visual acuity were presented on Table 2.

Table 2. Subject Characteristics of the Study (N = 81)

No.	Variables	Mean	SD	Range
1.	Age (th)	13.38	0.56	12.0-15.0
2.	Body weight (kg)	44.38	6.40	28.0-65.0
3.	Body height (cm)	154.74	6.17	133.0-167.0
4.	Right visual acuity (m)	6.58	0.10	6.1-6.9
5.	Left visual acuity (m)	6.60	0.11	6.1-6.9

N = Number of Sample SD = Standard Deviation

3.3 Data Normality and Comparability Analysis

Results of normality test on eye strain and musculoskeletal complaints by 1-S K-S test, the data obtained in both groups of subjects with normal distribution (p>0.05).

Results was not significantly different (p>0.05), based on t-paired test about eye strain and musculoskeletal complaints before learning in both types of treatment. The results of analysis indicated eye strain and musculoskeletal complaints as well before learning in both of subjects are comparable. Thus, the assumed reduction of eye strain and musculoskeletal complaints due to application of interior ergo-design of teaching-learning process. Results of analysis are presented in Table 3.

Table 3. Results of Comparability Analysis (N = 81)

Variables	Mean & SD of old interior design	Mean & SD of interior ergo-design	Mean difference	*t - paired*	*p*
Eye strain	9.27±0.46	9.25±0.43	0.02	0.32	0.75
Musculoskeletal complaints	29.84±0.71	29.74±0.63	0.10	0.93	0.36

N = Number of Sample SD = Standard Deviation

3.4 Analysis of Treatment Effect

Analysis on the difference after learning showed a significant different (p<0.05), based on t-paired test about eye strain, musculoskeletal complaints, and boredom after learning in both types of treatment. The results show, application of interior ergo-desain of teaching-learning process reduce eye strain, musculoskeletal complaints, and students' boredom of SMPN-3 Abiansemal Badung. Results of analysis are presented in Table 4.

Table 4. Results of Difference Test of Treatment Effect (N = 81)

Variables	Mean & SD on old interior design	Mean & SD on interior ergo-design	Mean difference	*t - paired*	*p*
Eye strain	3.91±0.65	2.16±0.51	1.75	19.18	0.002
Musculoskeletal complaints	13.28±2.60	6.51±1.62	6.77	19.30	0.003
Boredom	116.55±7.14	100.04±7.24	16.51	28.89	0.001

N = Number of Sample SD = Standard Deviation

IV. DISCUSSION

4.1 Environmental Condition

The result show, that environmental condition in interior ergo-design was qualified as a place to carry out to the teaching-learning activities. Lighting intensity was 365 lux of 199 lux previous, quite comfortable because the air temperature was 20-29ºC, relative humidity 66% from previous 82%, air movement of 0.20 m/d from the previous 0.13 m/d and sound intensity was 55dB.

Improving environmental condition in interior ergo-design, were done through a participatory approach with the management of SMP-3 Abiansemal Badung who have a policy with the use of natural lighting and electricity savings. By participatory approach resulted of translucent ceiling design to allow sun rise inside the interior with 6X70cmX110cm of holes. The light from the ceiling, reduced glare and contrast of light is that it comes from the side of windows. The conversion of 4 pieces a closed window can be opened, increasing the number of air circulation area. Smooth air circulation, keeping the stability of dry temperature and to prevent excessive wet temperature. Interior design with comfortable condition as a place of teaching-learning process, helping the students to use all of their energy for learning activities and not wasted to face with less learning comfortable environment condition (Sutajaya, 2004). Homeostasis system automatically adjusted the internal environmental conditions in the body, so that the bodys' core temperature remains within the range of 36-36.5ºC (Manuaba, 1998; Guyton and Hall, 2008; Pinel, 2009).

4.2 Subjects Characteristics

The mean age of samples is about 13.38±0.56 years. Student with age of 13 year is still in the phase of growth and development so rarely feel the complaint, unless the complaint rate exceeds his/her ability to overcome. One of the indicators used in estimating the physical and psychological maturity of a person, namely morphological age. A guideline is a body height, body weight and size of anthropometric that are related with age. Based on the chart issued by PVV Hamill (Sugiyanto, 2000), the child's growth chart issued by Srijoni (2004), the classification of child development and growth and nutritional status of children is used as the basis for assessment of the subject is expressed in normal conditions.

Based on the analysis on the subject characteristics, the condition of the subject is assumed to support this study because it is in healthy and prime physical conditions. Thus, increasing the students' performance as could be pointed out as a decrease in eye strain, musculoskeletal complaints, and boredom assumed to be caused by the application of interior ergo-design of teaching-learning.

4.3 Eye Strain

The result shows, eye strain was decrease about 1.75 or 44.76%, this decline indicates the physical condition of the subject as seen from the reduction in eye strain more better after learning on the interior ergo-design than when learning on the old interior design. The decrease of eye strain, caused by the intensity of illumination to facilitate the task of the iris and ciliarys' muscle in regularly and automatically to take place alternately. Visual objects hidden behind the board and the rest lay on the rear wall, so the number of visual objects should be viewed is limited. The number of visual objects in front of the eye, causing the prolonged sensory nerves contraction that encourages happen fatigue of synapse (Sherwood, 2001; Guyton and Hall, 2008; Pinel, 2009).

Dewi, et al. (2009) reported occurance of eye complaints in 63.30%, and its relation with long use of computers, inadequate lighting, age factor, and inadequacy and irregularity of the resting period. They found occurance of eye complaints had no relation with age, but had a relation with lenght of activity and rest frequency (p<0.05). Age factor influences elastisity of the eye lense, so eyestrain may easily occur. A study by Antari (2004) also reported the lighting intensity of the micro counseling room at IKIP Singaraja did not cause negative effect to the study subjects, bacause both the control group and treatment group got lighting intensity of 398.75 *lux* and 402.56 *lux*, respectively. Partadjaja (2004) reported that by increasing lighting intensity, he could increase working speed in 70.46%, working accurateness in 56.36%, and working constante in 90.95%. He also concluded that use of adequate lighting intensity could increase reaction speed and alertness sustainability in the study subjects.

4.4 Musculoskeletal Complaints

The analysis showed there has been a decrease in 6.77 or 50.98%, so musculoskeletal conditions of subjects is better after studying at the interior ergo-design than after studying at the old interior design. Decrease in musculoskeletal complaints in the interior ergo-design, influenced by the dynamic work posture while sitting because there are facilities for putting books and stationery on every desk. Every 40-80 minutes are available opportunity for standing and walking to the locker as storage of school bag under the board, the recovery process of muscle contraction becomes relaxation causing muscle refreshment. Reimbursement process of muscle contraction and relaxation causing the muscle energy to have reserves for the next contraction. Dimension of table and chair of teaching-learning process are designed in accordance of students' anthropometric analysis, so that the muscle is always in a physiological position for anytime needed.

Results of this study in line with those of Nachemson study on musculoskeletal complaints, increased pressure on the spine caused by an attempt to maintain body position in certain circumstances (Anannontsak and Puapan, 1996). Studies in 330 typists, showed symptoms of the most common musculoskeletal complaints of low back pain 53%, neck 50%, 27% hands and fingers 27.6%. Workers of glass bottle factory in India, work with repetitive postures cause injury in hand and wrist muscles by 40.6% (Bazroy et al., 2003). Musculoskeletal complaints is a first ranks among other occupational diseases and 44.9% cause

by the individual characteristics of age over 30 years (Bhattaherjee et al., 2003). Sore neck, shoulders, back and waist because of experience in static working cause 63% of workers (Evelyn, 1996). The results of this study, supported by research conducted Mekhora and Liston (2000) and Aarås, et al. (2001) reported a decline in the prevalence of musculoskeletal complaints after using the work station can be arranged as well as the frequency of adequate rest. After some study, Gerr and Letz (2000) suggested workstation ergonomic is determined by layout factors and dimensions of the workstation corresponding to anthropometrics and personal preferences. Gerr, et al. (2000) and Moffet, et al. (2002) suggests a similar principle with the addition of work posture should be physiologically. Musculoskeletal complaints are caused by lack of knowledge about the surface of the workstation, the tasks, organizing of work, equipment and workplace design does not meet user anthropometry, variations and work posture less physiologically during the activities was done (Chavalitsakulchai and Shahnavaz, 1993; Ayoub, 1996; Chau et al., 2002; Manuaba, 2003; Ketola, 2004).

Awareness on the importance of the body characteristics to the design to enhance movements is usually neglected. The work principle instructs that the human body or its parts should be moved, but should be given proper rest. If the body is less active, half of the muscles will make a long contraction, hence the organic complaints. Body position needed to be combines, because of the rhythmic muscle movement helps the smooth circulation of blood that contains nutrients and oxygen.

4.5 Boredom

The analysis showed there has been a decline in 16.51 or 14.17%, so that subjects who studied in the interior ergo-design have lower values of boredom than subjects who studied in the old interior design. Decrease of boredom after studied in the interior ergo-design, available by interior bright colors closed reddish color made possible lead to make it more memorable excited but keep the atmosphere of careful work (Anderson, 2009). This result in line with research was conducted by Wignjosoebroto et al. (2005) to copes boredom. Reported that playing music could increase work productivity without having to play it all around the working hours because otherwise it may cause boredom. Music therapy would be more successful if each worker was given a chance to play the musical instrument or sing the song along. The results of this study illustrates, boredom can be minimized if the person given the opportunity to be actively involved as an effort to self-actualization (Manuaba, 2005). Interior ergo-design has an appeal means, because the board is available along the front of the classroom wall while behind it tacked various types of information and communication media when every morning and afternoon should be viewed and updated data. Sliding whiteboard can be shifted to give a new value for students who have a high curiosity, encourage more creative at every opportunity to be creative.

Design of ceiling as a place of lamps as well as a place of sun rise to allow into the interior and remove the CO^2 that filled the interior by respiration, providing inspiration for the subject to innovate. Boredom can reduce the stimulus mechanisms of response, on the nervous and muscles system. According to the theory of physiology, any stimulus to the central nervous system is influenced by physical and mental triggers. If the stimulus is weak, reaction of the organism decreases. This latter condition results in a gradual decrease of endurance to concentrate over a certain subject, thus needing a new other stimulus to regain alertness or concentration (Grandjean, 2000).

V. CONCLUSION

Our findings implied that interior ergonomic design intervention has led to the following outcomes: enhancing the student performance by decreasing eye strain by 44.76%; musculoskeletal complaints by 50.98%; and boredom by 14.17%. The beneficial outcomes of our intervention appeared to be obvious.

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