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Evaluation of Student Mental Workload in Multicampus Lectures of Industrial Engineering Department' Block System

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ABSTRACT

This study focuses on the Industrial Engineering (IE) study program at the Bandung Institute of Technology Cirebon Campus, which offers block and non-block system lectures. The block system is a lecture combining two to three class meetings of a course into a single day, while the non-block system is a one-time meeting every week. Students voiced objections about the block system due to the difficulty of receiving a large amount of quantitative content, the hectic schedule, and the monotonous nature of the lessons. Through a comparison of experimental measurement results from students attending block and non-block classes, this study evaluates the mental workload of students. Three instruments were used to measure the mental workload: the NASA-TLX, the Karolinska Sleepiness Scale (KSS), and the Stroop test. Thirty-eight students participated in the experiment. The results showed that there is no significant difference in the mental workload between the two systems, as shown by the score of the NASA-TLX, KSS, and Stroop test. These outcomes could be the result of several factors such as prior block class experience, less instructional time under the block system, student mental fatigue, and a diminished attention span.

Keywords: *mental workload; block system; NASA-TLX; KSS; Stroop test*

1. Introduction

The gross participation rate in higher education is the proportion of the population studying in higher education to the total population in the college-age range (19-23 years old) (Habibah et al., 2019). According to Badan Pusat Statistik (BPS) in 2022, Indonesia's gross participation rate in higher education is still relatively low at 31.16% and has not reached the minimum value of developing countries of 36%. As a result, Indonesia's percentage value is significantly lower than of its neighbours, Malaysia, the Philippines, and Thailand.

To increase the gross participation rate in higher education, the Ministry of Research, Technology, and Higher Education is implementing a multicampus lecture system. The primary objective of multicampus education is to facilitate learning between students and lecturers in multiple places, but the objectives and mission are the same on every campus (Groenwald, 2018). Another approach to describe multicampus higher education is geographically dispersed institutions that are connected by a single system (Nicolson, 2004). Because there is a limited amount of land and capacity on the main campus, this multicampus concept gives people in remote areas more opportunities to access education and allows universities to accommodate more students.

The government of Indonesia, particularly its region of West Java, works with several universities, including the Bandung Institute of Technology (ITB), in support of multicampus policies. ITB has operated as a multicampus organization since 2010 and as a result of the decision it currently has campuses in four different locations: Ganesha Campus, Jakarta Campus, Jatinangor Campus, and Cirebon Campus. One of the study programs that is offered in two locations, Ganesha and Cirebon, is Industrial Engineering (IE). IE Cirebon Campus lectures are conducted using two distinct lecture mechanisms block system and non-block system-they it differs from Ganesha in terms of implementation. In a non-block system, there is only one class meeting per day, whereas in a block system, there are two or more class meetings combined into one lecture.

The United States educational institutions have been using the block system for a very long time. It is believed that learning using a block system gives students more time to review the content, which lowers their exam failure rate (Said & Gozdzik, 2020). According to a study that compared how effectively students performed academically in block and non-block classes, block-class students outperformed non-block students because they

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were able to study more deeply and critically. This could happen because students were only focused on one subject at a time. In the other research, the block system was found to have no different effect on students' academic performance and cognitive achievement (Moroney et al., 1992).

Meanwhile, the implementation of the block system is believed to be the reason for the shortcomings that exist on the Cirebon Campus, such as the majority of lecturers are domiciled and have a work base in Bandung. Furthermore, because the distance between Bandung and Cirebon is 129.8 kilometers or two hours by car, time efficiency and minimizing the amount of mobilization are considerations. Nonetheless, IE students frequently complain about the block system for a variety of reasons, among them lectures that they find to be overly busy, their incapacity to take in a large amount of quantitative material at once, and their generally boring classes.

Research will be conducted to assess the level of student's mental workload during the lecture. As it related to the academic learning outcomes and activities of students studying industrial engineering, this research is necessary to conduct. The more work that needs to be done, the sooner mental dan physical health will tire. In addition, students' motivation to learn and capacity for information processing might be diminished if they are consistently exposed to high mental loads (Said & Gozdzik, 2020). Students who experience difficulties in processing information find it harder to absorb and comprehend lecture material, which can have negative long-term consequences if left untreated. It is anticipated that the study's findings can be used as assessment material and encouragement for new ideas aimed at enhancing the effectiveness and efficiency of lectures.

2. Method

2.1. Participants

The research participants consisted of 38 students from two-course classes: Service Product Systems (Sistem Produk Jasa) and Introduction to Industrial Engineering (Pengantar Teknik Industri). In detail, the participants consisted of four students from the class of 2019 (10.52%), four 4 students from the class of 2020 (10.52%), ten students from the class of 2021 (26.32%), and twenty students from the class of 2022 (52.63%). At the time of measurement, all participants were in good health.

2.2. NASA-TLX

NASA-TLX is a widely used multi-dimensional workload measurement tool. NASA-TLX consists of six-dimensional measures with three dimensions related to demands on the job (mental demand, physical demand, and temporal demand) and three dimensions related to how the worker handles the job (performance, effort, and frustration level).

There are two NASA-TLX methods: weighted NASA-TLX and raw NASA-TLX. Despite being more frequently used, weighted NASA-TLX still has limitations, such as the possibility of inconsistent pairwise comparisons and the certainty that if a dimension weights 0, the overall dimension score will be 0. According to certain studies, weighted NASA-TLX is more complex to implement and requires more time than raw NASA-TLX (Said and Gozdzik, 2020). However, a comparison of simulated flights between weighted NASA-TLX and raw NASA-TLX measurements found no significant difference between the two methods (Moroney et al., 1992).

2.3. Karolinska Sleepiness Scale (KSS)

The Karolinska Sleepiness Scale (KSS) is an instrument for measurement used to assess sleepiness on an individual basis. The KSS is used in studies related to driving activities, attention, and performance and has been validated using alpha and theta electroencephalographic (EEG) (Kaida, 2006). Slower reaction times are believed to be the consequence of lower performance caused by higher KSS scores (Hoddes & Zarcone, 1973). Based on other research, there is a strong correlation between performance and subjective sleepiness, meaning that an increase in KSS score will be accompanied by a decrease in performance.

With the KSS instrument, measurement can be measured using nine verbal scales consisting of (1) very alert; (3) alert; (5) neither alert nor sleepy; (7) sleepy; and (9) very sleepy, fighting sleep. Even though they do not have addressed labels, points in the middle between the scales have values (Akerstedt & Gillberg, 1990).

2.4. Stroop test

The Stroop test is a word-colour test used to assess selective attention and cognitive flexibility (Homack & Riccio, 2004). The Stroop test can also be used to assess an individual's capacity for information processing, attention span, and response inhibition (Barwick et al., 2012). According to other research, the Stroop test assessed how much interference affects attention (Linman & Andersson, 2006). Several versions of the Stroop test are widely used, but in general, the test asks subjects to name the color of the words regardless of their meaning or, conversely, to name the word regardless of the color of the ink. The test's outcomes reflect the impact of interference, which causes an increased test response time.

The Stroop test used total time and total error as its parameters (Barwick et al., 2012). Based on other studies, the overall time, mean time per word, and the total number of uncorrected errors are the parameters used in the Stroop test. Many Stroop tests were previously taken on paper, but due to their accuracy and practicality, computer-based Stroop tests are now more frequently used. The "Stroop Effect Test" application, which can be downloaded from the Google Play Store, was used in this study.

2.5. Procedures

The research was conducted through experiments in an actual lecture setting to obtain more realistic results. On the same course, experiments were done on two different scenarios: block system and non-block system.

Participants were instructed to install the Stroop test application and get enough sleep the day before the experiment. In the non-block system scenario, participants were asked to complete the KSS questionnaire and the Stroop test as part of data collection prior to a lecture. On the other hand, the NASA-TLX was completed at the start of the class. Participants are also required to attend lectures in a proper and appropriate manner. Following the lecture, participants were required to complete the NASA-TLX and KSS as well as the Stroop test for the second time.

The block scenario used the same procedures and data collection methods, but additionally allocates data collection time to occur both before and after the second lecture. This is used to ensure that the 150-minute gap between the two experiments is the same. The difference between the values from the two systems' before and after is the value of the dependent variable that will be compared. A different experiment duration will result in an unbalanced measurement that is incomparable. Furthermore, participants from the same course are involved in the experiment to reduce the number of uncontrollable variables that could affect the dependent variables.

2.6. Data Processing

Data processing involved determine the final score and performed the normality test. The purpose of the normality test is to figure out the type of data distribution. Numerous normalcy tests are frequently used, such as Kolmogorov-Smirnov, Liliefors, Anderson-Darling, and Shapiro-Wilk. Nonetheless, due to its superior power over alternative tests, the Shapiro-Wilk test is highly advised. When evaluating a normality test, one measure that is utilized is power (Ghasemi & Zahedials, 2012).

Further testing is a test of differences. There are two statistical tests to determine if there is a significant difference between two mutually independent sets of data: the independent sample t-test and the Mann-Whitney U-Test. The Independent Sample T-Test test is used if the results of the previous normality test indicate that the data is normally distributed; if not, the Mann-Whitney U-Test test is used.

3. Results

The complete data collected from the measurement process include four NASA-TLX questionnaire data (before and after block lectures and before and after non-block lectures), four KSS data, and four Stroop test results data. Following the collection of data, it will be processed and put through a series of tests. Table 1 and Table 2 are the recapitulations of mental workload measurements.

Table 1. Recapitulation of Mental Workload Measurement of Non-Block Lecture System

Method	Parameters	Average		
		Before	After	Difference
Subjective: NASA-TLX	Mental Demand	45.79	54.08	8.29
	Physical Demand	30.92	36.58	5.66
	Temporal Demand	47.63	52.24	4.61
	Performance	43.82	47.50	3.68
	Effort	55.53	58.68	3.16
	Frustration Level	35.79	39.47	3.68
	NASA-TLX Score	43.25	48.09	4.85
Subjective: *KSS*	KSS Score	3.29	4.34	1.05

Performance:	Total Time	62.28	65.85	3.56
Stroop Test	Total Error	0.82	1.87	1.05

Table 2. Recapitulation of Mental Workload Measurement of Block Lecture System

Method	Parameters	Average		
		Before	After	Difference
Subjective: NASA-TLX	Mental Demand	50.66	58.55	7.89
	Physical Demand	40.92	46.58	5.66
	Temporal Demand	59.47	63.68	4.21
	Performance	48.82	51.11	3.29
	Effort	58.95	64.47	5.53
	Frustration Level	39.34	46.32	6.97
	NASA-TLX Score	49.69	55.29	5.59
Subjective: *KSS*	KSS Score	3.76	5.29	1.53
Performance: *Stroop Test*	Total Time	64.52	68.42	3.91
	Total Error	1.39	2.63	1.24

The following step is to determine the difference between the two measurements. For each type of lecture system, the tested difference value is calculated by deducting the after value from the before value. As the data is normally distributed, the independent sample t-test (α = 5%) is used as the difference test in the NASA-TLX measurement results. Meanwhile, KSS and Stroop test results are not normally distributed, so the Mann Whitney U-Test (α = 5%) will be used. The test results show that all *p-values* are less than α = 5%, indicating that the data are not significantly different for any parameter. The test results are summarized in Table 3.

Table 3. Independent Sample T-Test and Mann Whitney U-Test Result

Methods	Parameters	Difference		*p-value*
		Block	Non-Block	
Independent Sample T-Test	Mental Demand	8.29	7.90	0.91
	Physical Demand	5.66	5.66	1.00
	Temporal Demand	4.61	4.21	0.91
	Performance	3.16	5.53	0.91
	Effort	3.69	3.29	0.44
	Frustration Level	3.69	6.97	0.38
	NASA-TLX Score	4.85	5.59	0.86
Mann Whitney U-Test	KSS Score	1.05	1.53	0.21
	Total Time	3.57	3.91	0.64
	Total Error	1.05	1.24	0.27

4. Discussion

4.1 Comparison of block and non-block systems

The study's findings indicated that there was not a significant difference between students' mental workloads in block and non-block classes. The results of this research are consistent with those published by Labak and Radanovic (2020), who found no significant variations in students' performance between block and traditional classes (once a week). This outcome is the result of several factors, including the following: (i) students have previously attended block classes; (ii) the topics being learned are complex; and (iii) students' ability to comprehend and make connections between concepts on their own, using knowledge and analytical abilities.

Similar findings are found in another study by Ratchliff & Pritchcard (2014), which shows that despite block class students lower End of Course Tests (EOCT) than those of non-block classes, there is no significant difference in student performance between block and non-block classes. The results of block-class students are lower than those of non-block classes. According to this research, other factors, such as the use of instructional time that is not optimal, which results in students losing attention, cause significantly greater differences in performance than the lecture mechanism. Extended periods of instruction can facilitate more in-depth conversations between instructors and students, but they can also lead to boredom, difficulty concentrating, and trouble understanding what is being taught (Wedel & Freundl, 2022). Based on Randler & Konstanze (2008), using a blocked class system to teach does not yield better performance outcomes than using weekly schedule because learning is less effective in block classes because a greater amount of time is lost on unrelated activities than instruction.

4.2 Stroop test performance

As revealed by the results, students' response times were longer and their accuracy levels were lower under the block system than under the non-block system, even though the average difference between the two systems was not statistically significant. These findings are in line with a previous study that found an inversely proportional relationship between response time and accuracy level, or the "speed-accuracy trade-off". An increase in the time required to respond is correlated with a decline in accuracy, which in this study is represented by an increase in the number of errors (Liesefeld & Janzcyk, 2019).

Mental fatigue factors may contribute to low student performance and continuous work can lead to mental exhaustion. When someone is mentally tired, their sustained attention is reduced, which leads to processing errors and a worsening of their response time. The process of processing errors involves a sequence of mistakes in identifying issues, acting appropriately, and monitoring problems (Xiao & Ma, 2015).

Another factor to consider is that during block classes, students must maintain their focus on paying attention to lectures for a longer period than in the non-block system. According to Reteig (2019), prolonged work requiring constant attention leads to mental fatigue and poor performance. A prolonged attention span will demand more effort, which increases the mental workload associated with the activity. Poor performance and mental fatigue are the results of a higher mental workload brought on by a simultaneous increase in effort.

5. Subjective mental workload

Subjective-based mental workload measurement is carried out with NASA-TLX and KSS measuring instruments. According to Morales et al. (2020), NASA-TLX scores can be interpreted into four categories: low (0-25), medium (26-50), high (51-75), and very high (76-100). As a result, it is determined that the average NASA-TLX score for non-block lectures is in the medium before the lectures. For block lectures, nevertheless, there is a shift in scores from the medium category to the high category after the lectures.

No significant difference between the two lecture systems can be caused by the cultural factors of participants. It has been implied that Indonesian participants are conservative when providing ratings during subjective measurement, based on Johnson & Widyanti (2011). The study also revealed that Indonesian participants had a tendency to assign a lower value to perceived differences than to actual ones, which resulted in ratings that occasionally did not correspond to participants' actual circumstances. This might happen as a result of Indonesian participants giving a moderate assessment during the measurement because they believe they are powerless to alter the situation.

An analysis of the NASA-TLX score alone is not sufficient to determine the final score because an analysis of the six dimensions is also required. Since every dimension in NASA-TLX represents a distinct load, an analysis of every dimension is required. The measurement indicates that, although there is no statistically significant difference, the dimensions of mental demand have increased the most in both block and non-block systems when compared to other dimensions. Individual characteristics and factors related to the learning sequence may impact the extent of the increase in mental demand (Kyndt et al., 2014). The learning part, assignment, topic difficulty, and content of the material studied can all have an impact on how much work students feel they are required to complete. Meanwhile, interest in referred to has an impact on students' perceptions of their workload from the individual characteristic factor.

When each dimension of NASA-TLX is examined, the dimensions of mental, physical, and time requirements are influenced by job complexity. On the other hand, awareness of the demands of the work itself leads to the effort dimension. In order to allow for variations between actual and predicted conditions, the performance dimension is defined by individual characteristics. The amount of tension experienced both before and during work determined the dimension of frustration level. Because there is no significant difference, it can be concluded that the burden of observing to block system lectures is minimal.

On the other hand, the measurement results with the KSS instrument show that the average KSS score of the block class system is greater than that of non-block system. Research by Okano & Kaczmarzyk (2019) states that an increase in sleepiness levels will cause fatigue. In addition, sleepiness also causes a decrease in a person's memory and attention functions, so academic performance will tend to decrease. Other studies provide conclusions that are in line with the conclusion that more time students spend in class over time will cause increased sleepiness and decreased alertness. Increased sleepiness can affect attention, which in turn affects student performance. However, other factors may affect the level of sleepiness during class such as the way the material is presented during lectures (Hosteng & Reicher, 2019).

6. Recommended solutions

Suggestions for minimizing the cognitive load encountered by learners are provided. Since there are a number of factors that affect students' workload, including learning styles, time allocated for different activities, and institutional factors such as teacher and educational institutions, recommendations are not only for to students but also to lecturers and study programs (Bowyer, 2012). Based on the measurement and analysis, although the mental workload was not significantly difference, the block system resulted in lower performance, a change in the NASA-TLX score from moderate to high, and an increase in sleepiness. This occurs due to the onset of mental fatigue in students. Mental fatigue then causes other problems such as decreased attention, error processing, and increased sleepiness.

1) Lecture activities are not filled with material, but are interspersed with other activities.

Based on analysis of the measurement results, the block system causes an increase in drowsiness characterized by an increase in KSS scores, worse performance than the block system characterized by lower measurement results, and mental fatigue. These factors cause a decrease in sustained attention. Therefore, it is recommended that lecture activities are not filled with providing material, but accompanied by other activities. The existence of other activities in lectures aims to prevent the decline of student attention, reduce monotony during lectures, and increase student alertness.

Bowyer (2012) provides advice that learning activities are carried out using a variety of teaching methods. The research also provides advice on the ratio of time used for teaching to the time that can be used for independent student activities. The following recommendations for the ratio of lectures can be done as follows.

a. Instruction and supervise practice with a time ratio of 1:3. In light of this, this alternative can be used to allocate 50 minutes for material provision and 150 minutes for question practice under guidance of the lecturer in a 200-minute two-credit block class.
b. Instruction and group learning with a time ratio of 1:5. Group learning can discuss a problem on the topic being studied. Group learning with fewer members (less than five) is recommended so that more interaction and discussion are possible. Discussion activities are suggested to prevent the loss of students 'attention if they only continue to pay attention for a long time.
c. Instruction and presentation with a time ratio of 1:3. With a time ratio of 50 minutes is filled with activities that require students to present their opinions on the topic being studied.

In line with additional research, classroom learning activities consist of three main components: (1) material delivery; (2) collaborative exercises between students; and (3) classroom discussion (Morris, 2022). Another alternative to consider is to ask questions at the conclusion of the first class, which will then need to be addressed and resolved in the second session. This can break up the routine and get students to pay attention again.

2) Implementing active learning strategies

According to an analysis of the measurement results, one of the reasons why students perform poorly and have a heavier mental burden is a decrease in sustained attention. This suggested solution aims to prevent students from paying less attention or shortening the amount of time they spend maintaining sustained attention on the same activity. Mosteanu (2021) states one method for increasing and maintaining attention during learning is to use active learning techniques. The following methods can be used to implement the active learning strategies.

a. *Case studies*
As an alternative to traditional case studies, students are provided with an actual case related to the subject matter of the study, which can be found in scholarly journals or news articles. Students then examine and

analyze this case, either individually or in groups. The result of the analysis can be presented in front of the class or turned in as a collection of written works.

b. *Think-Pair-Share*
There are three phases to this alternative. In the first phase, known as Think, students consider the given problem on their own. Students discuss the outcomes of their earlier thinking in pairs during the next phase, known as Pair. Students share the outcomes of the discussion with other students in the class during the final phase, also known as Share.

c. *Debate and Discussion*
The following alternative is to have class debates and discussions. Students are asked to engage in discussion with one another about the ideas or issues being discussed in the debate alternative. This approach offers students the chance to develop their critical thinking abilities in addition to helping them pay attention. In the discussion alternative, students work in groups to share their ideas and opinions on a subject or engage in cooperative activities that help them both comprehend the concept of the subject matter being studied.

Conclusions

The evaluation results indicate that although the mental workload of IE students at ITB Cirebon Campus in block system lectures is greater than in non-block system lectures, there is no significant difference in load between the two systems. According to the performance-based evaluation, students in the block system responded more slowly and were less accurate. The same conclusion has been reached by the subjective evaluation as well. The NASA-TLX measurement tools showed three dimensions that increased the most during block classes: frustration, physical demand, and mental demand. The Karolinska Sleepiness Scale (KSS) revealed that block systems' measurement outcomes are higher than those of non-block systems. The suggested solutions include using case studies, think-pair-share, debate, and discussion, as well as alternate lectures that incorporate multiple activities. Other suggestions include balancing the amount of time spent on material delivery with other activities.

Some recommendations are made for future research. Conduct research with participants from more than two courses. Because of the limited number of courses that are suitable as experimental objects due to irregular class schedules, participants in this research were limited to two courses. More participants in the research can increase the statistical testing power. Another recommendation is to measure at the start, middle, and end of the semester in order to conduct additional research. Due to a lack of research time, this study only measured mental workload at the beginning of the semester. An overview of the likelihood that the block system will have a major impact at a particular point in time can be obtained through measurements throughout the semester.

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