BIS ENERGY AND ENGINEERING

Volume 2 2025 | DOI: 10.31603/biseeng.213
6th Borobudur International Symposium on Science and Technology (BIS-STE) 2024

UNIMMA PRESS
Universitas Muhammadiyah Magelang

Measurement mental and physical workload in final-year thesis students in the faculty of engineering at Universitas Muhammadiyah Cirebon

Budi Susanto[1*], Harry Gunawan[2], Bastoni[3]

[1] Industrial Engineering, Universitas Muhammadiyah Cirebon, Cirebon, Indonesia
[2] Informatics Engineering, Universitas Muhammadiyah Cirebon, Cirebon, Indonesia
[3] Animal Husbandry Engineering, Universitas Muhammadiyah Cirebon, Cirebon, Indonesia
[*] Corresponding author email: budi.susanto@umc.ac.id

Abstract

Students who are writing a thesis often experience difficulties. The difficulties faced are diverse, ranging from a lack of understanding of the phenomenon being studied, a lack of mastering the theory, limited references, and so on. This will cause a mental burden that impacts student fatigue which causes a decrease in efficiency, endurance, and work capacity. The research was conducted at the Industrial Engineering, Faculty of Engineering, Muhammadiyah University of Cirebon. This study uses the NASA-TLX and CVL methods which aim to measure the physical and mental workload of the final project students at the Industrial Engineering Study Program and make proposals for improvement and comparison of the results of physical and psychological workload scores. The results showed that the NASA-TLX score load on mental demand, physical demand, temporal demand, performance, effort, and frustration level was 79.37, 59.61, 65.5, and 64.5. CVL score load obtained physical workload value 6 students have CVL value of 30% - 60% which falls into the category of needed improvement. There are 14 students with a CVL value of 30% falls into the category of no fatigue. After being given recommendations for proposed improvements, the results of CVL 6 students have decreased CVL results. Based on the results of the two methods, CVL is more dominant than the results of the NASA-TLX method. Proposed improvements given to reduce mental and physical workload are a closed workspace layout, providing music, and conducting ESQ training.

Published:
May 31, 2025

Selection and Peer-review under the responsibility of the 6th BIS-STE 2024 Committee

Keywords

Physical and mental workload, NASA-TLX, Cardiovascular load (CVL)

Introduction

The quality of students is increasingly becoming a concern of university managers because it plays an important role in supporting the creation of a high-class learning process. In the learning process, students are required to be more independent; therefore, few students experience learning difficulties, so they get less than optimal

learning results. In general, students who are writing a thesis often experience difficulties. The difficulties faced are diverse, ranging from not understanding the phenomenon being studied, not mastering the theory, limited references and so on [1]. Workload is the type or kind of task that a person accepts to work within their capacity and work within a certain time. A person's capacity (capability) is the various potential aspects (physical and mental) that a person has, namely gender, age, body size, health conditions, education level, experience as well as aspects of the social environment. The workload itself has two internal and external factors. The workload is divided into two categories, namely physical load and mental load. Humans essentially consist of body and soul or mental and physical. Since birth, it has been like that, two aspects that cannot be separated or ignored the existence of one of them [2]. The objectives of this study are to measure the physical and mental workload of faculty engineering UMC final project students, make suggestions for improvement, and comparison of the results of physical and mental workload scores using the NASA TLX and CVL methods.

Method

The respondents involved in this research consisted of 20 students in the eighth semester of an industrial engineering program. The number of male respondents is 18 and the number of female students is 2. The average age of respondents is 22 years old. The research method is a process or description of the research to be carried out. There are several important stages in carrying out this research. The stages that must be carried out to support this research are Observation (Observation is direct observation of the research object. Observation is carried out to see the actual conditions of the studied object), Interview (a method of data collection, namely asking directly to the source. Questions are adjusted to the topic to be discussed. In this study, interview questions asked about what problems existed in compiling the thesis), NASA-TLX Questionnaire (method of written questions asked to respondents related to the problem topic to be discussed. Questionnaires are also used in data collection for several data processing methods), Pulse measurement (Pulse measurement is done using an Oximeter. Pulse data collection time is 3 times, namely before the study, while studying, and also during rest).

Data collection carried out in this study is a process for searching and mining data to be used in the analysis process. Data collection is carried out by direct observation of final-year students in the engineering faculty. The results of observations are population and research samples:

Research population

This study's population is all individuals with specific characteristics that tend to be the same, which the author determines to study, and then conclusions can be drawn.

Research sample

The research sample is part of the population that has the same characteristics as the population. This sampling technique uses a probability sampling technique, namely sampling, that provides equal opportunities for each element of the population to be selected as a sample.

NASA-TLX Method

The NASA TLX (National Aeronautics and Space Administration Task Load Index) method is a method for analyzing the mental workload faced by workers who must carry out their work activities [3]. The NASA-TLX strategy has two main steps, namely the level of giving weights and the level of giving ratings:

a. Weighting stage. At this stage, a workforce of 15 pairs of dimensions must choose the one that has the most influence to get the job done. Respondents were asked to rate six dimensions with scores ranging from 0 to 100.

b. Rating stage. At this stage, the respondent workforce is asked to rate the six dimensions on a scale from 0 to 100. If the weights and scores for each dimension are obtained, the WWL and average WWL for each respondent can be calculated. "The calculation of the product can be done with Equation (1), and the calculation of the total WWL is done in Equation (2). Also, the average WWL is done based on Equation (3).

$$\text{Product} = \text{Rating x Weight} \tag{1}$$

$$\text{WWL} = \sum_{i=1}^{6} \text{Rating(i)x Weight(i)} \tag{2}$$

$$\overline{WWL} = \frac{WWL}{15} \tag{3}$$

The table of NASA-TLX aspects [6]:

Table 1. NASA-TLX aspect

No	Scale	explanation
1	Mental Demand (MD)	Mental activity is needed when carrying out work (thinking, seeing, remembering, calculating, and searching)
2	Physical Demand (PD)	Physical activity required in the job (lifting, pushing, and walking)
3	Temporal Demand (TD)	Time pressure is felt during work or work elements in progress
4	Performance (OP)	success in achieving work targets and performance in achieving company targets
5	Frustration Level (FR)	The effort put forth both mentally and physically that is required to achieve a level of performance
6	Effort (EF)	feeling insecure, hopeless, offended, stressed, and disturbed compared to feeling safe, satisfied, and comfortable while doing the job

According to the explanation of Hart and Staveland 1981 (Nurdin et al., 2022), the workload class is divided into Table 2:

Table 2. Classification workload

Workload Category	Scale
Very low	0-9
Low	10-29
Moderate	30-49
High	50-79
Very High	80-100

Cardiovascular load (CVL) Method

The Cardiovascular Load (CVL) method measures physical workload based on the origin of the comparison between the work pulse rate using the maximum pulse rate. CVL percentage is a calculation to select the workload description according to the increase in work pulse rate compared to the maximum pulse rate [4]. The steps for measuring physical workload in CVL percentage are:

a. Calculating the work pulse rate (DNK) of final project students at 07.00-16.00 hours. The calculation of DNK is done by calculating the average pulse rate in 1 day, namely:

1) DNK's first measurement at 07.00-09.00 WIB.

2) DNK's second measurement at 10:00-12:00 WIB.

3) The third measurement of DNK is at 13.00-15.00 WIB.

Furthermore, the measurement of Resting Pulse Rate (DNI) was carried out three times in one day, namely 09.00-10.00 WIB, 12.00-13.00 WIB, and 14.00-15.00 WIB. To obtain the DNK and DNI values, the equation used is:

$$\text{Heart Rate}\left(\frac{\text{pulse}}{\text{minute}}\right) = \frac{10\ pulse}{time\ calculation}\ x\ 60 \qquad (4)$$

b. Calculating the maximum pulse rate

The subjects of this study were final project students of the engineering faculty, so the equation was used to calculate the maximum pulse rate:

$$\text{DN Max} = 220 - \text{age} \qquad (5)$$

c. Calculating the work pulse

The next step is to calculate the work pulse in the equation:

$$\text{work pulse} = \text{DNK} - \text{DNI} \qquad (6)$$

d. Calculating the percentage of CVL (%CVL)

calculate the percentage of CVL with the equation:

$$\%\text{CVL} = \frac{100\ (working\ pulse\ (\text{DNK}) - \text{resting pulse (DNI)})}{\max pulse\ (\text{DNmaks}) - \text{resting pulse (DNI)}} \qquad (7)$$

The results of the % CVL calculation are then compared to the predetermined categories:

Table 3. Classification CVL

No	% CVL	Category
1	< 30%	No Fatigue
2	30% - < 60%	Required repairs
3	60% - < 80%	Work in no time
4	80% - < 100%	Immediate action required
5	>100%	Not Allowed to move

Results and Discussion

Workload Analysis Using the NASA-TLX Method

The NASA-TLX method is used to describe the mental workload experienced by students who are required to carry out various thesis research activities. Students often experience dizziness due to the high demands of thesis supervisors and eyes tired from looking at the laptop screen for too long. The effects of radiation are also very influential on students, and they often experience weakness due to lack of sleep. The length of study time causes complaints of stress, easy boredom, drowsiness, and mental workload.

This research mental workload measurement uses the NASA-TLX method to determine the mental workload score received. Also, the NASA-TLX method is a multidimensional method that has six subscales, namely mental demand (MD), Effort (EF), Frustration Level (FR), Temporal Demand (TD), Physical Demand (PD) as well as Performance (OP). From the results of the NASA-TLX questionnaire, mental demand (MD) workload is an aspect that looks at how much learning activities require physical and psychological work, such as seeing, remembering, and calculating. The overall average value of the MD aspect is 79.00. Effort (EF) is an aspect that looks at how much effort, both physical and psychological, students put in to achieve the set targets. The overall average value of the EF aspect is 65.5. Frustration Level (FR) is an aspect that looks at the level of student frustration, such as despair, discomfort, and annoyance experienced while carrying out activities. The overall mean of the FR aspect is 64.5. Temporal Demand (TD) is an aspect that looks at how much work activities get time pressure during study. The overall mean value of the TD aspect is 59.00. Physical Demand (PD) is an aspect that looks at how much work activity requires physical activity in doing work such as pushing, pulling, running, and controlling. The overall average value of the PD aspect is 37.00. Performance (OP) is an aspect that looks at worker satisfaction with the performance carried out to achieve the set targets. The average value of OP is 61.00.

Physical Workload Analysis Using the CVL Method

Table 4. Cardiovascular Load Result Value Before Implementation

Result Value Before Implementation %CVL		
INITIAL	**%CVL**	**Category**
AR	**8,11**	**No Fatigue**
D	27,78	No Fatigue
SR	20	No Fatigue
SH	19,84	No Fatigue
RS	31,3	Required repairs
RY	34,93	Required repairs
SA	35	Required repairs
TK	17,27	No Fatigue
L	20,59	No Fatigue
NY	24,76	No Fatigue
A	15,93	No Fatigue
MI	21,78	No Fatigue
AB	30,77	Required repairs
Y	33,85	Required repairs
H	36,29	Required repairs
AM	27,78	No Fatigue
AP	22	No Fatigue
AZ	14,85	No Fatigue
F	23,58	No Fatigue
S	28,15	No Fatigue

Table 5. Cardiovascular Load Result Value After Implementation

No	Initial	DNMAX	CVL Before Implementasi (%)	CVL After Implementasi (%)
1	AR	192	8,11	7,02
2	D	160	27,78	26,88
3	SR	171	20	14
4	SH	194	19,84	19,38
5	RS	188	31,3	24,81
6	RY	168	34,93	31,54
7	SA	194	35	28,17
8	TK	192	17,27	8,93
9	L	184	20,59	14,29
10	NY	168	24,76	17,24
11	A	187	15,93	13,79
12	MI	186	21,78	11,54
13	AB	187	30,77	10,53
14	Y	179	33,85	14,68
15	H	170	36,29	18,37
16	AM	165	27,78	15,73
17	AP	177	22	14,29
18	AZ	183	14,85	7,84
19	F	194	23,58	10,34
20	S	191	28,15	15,13

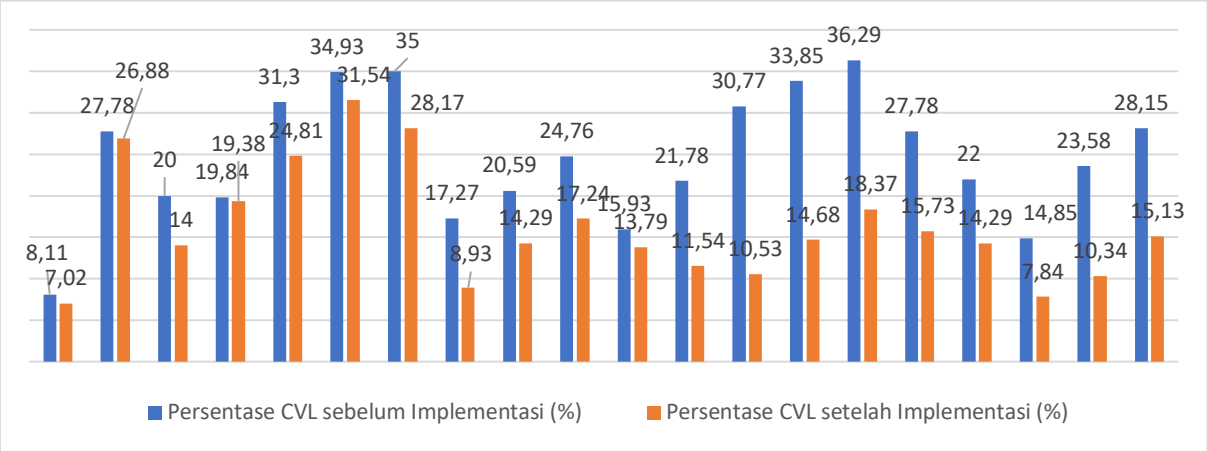

Figure 1. Comparison %CVL (Before and after Implementation)

Based on Table 5, the results of Figure 1 show that RS students experienced a decrease in CVL percentage from 31.30% to 24.81%. RY students experienced a decrease in CVL percentage from 34.93% to 31.54%. SA students experienced a decrease in CVL percentage from 35% to 28.17%. AB students experienced a decrease in CVL percentage from 30.77% to 10.53%. Students experienced a decline in CVL percentage from 33.85% to 14.68%. While student H experienced a reduction in CVL percentage from 36.29% to 18.37%, students with a CVL presentation of 30% - <60% had made improvements, so they experienced a decrease in CVL percentage results after being given the proposed improvements.

Comparison of NASA-TLX and CVL methods

Based on the final results using the two methods, the score or value of each method is obtained. The Cardiovascular Load method is a method that evaluates physical workload objectively by measuring pulse rate, while the NASA-TLX method is a method that evaluates mental workload, which is subjective. The following is a recapitulation of the results of the values of the two methods in the form of Table 6.

Table 6. Recapitulation of the results of the values of the two methods

No	Initial	Results			workload classification
		%CVL method	workload classification	NASA- TLX method	
1	AR	8,11	No Fatigue	74	High
2	D	27,78	No Fatigue	76,67	High
3	SR	20	No Fatigue	66	High
4	SH	19,84	No Fatigue	68	High
5	RS	31,3	Required repairs	76,67	High
6	RY	34,93	Required repairs	76,67	High
7	SA	35	Required repairs	76,67	High
8	TK	17,27	No Fatigue	85,67	Very High
9	L	20,59	No Fatigue	76,67	High
10	NY	24,76	No Fatigue	86,67	Very High
11	A	15,93	No Fatigue	76,67	High
12	MI	21,78	No Fatigue	66,67	High
13	AB	30,77	Required repairs	66,67	High
14	Y	33,85	Required repairs	72,67	High
15	H	36,29	Required repairs	86	VeryHigh

No	Initial	Results			workload classification
		%CVL method	workload classification	NASA- TLX method	
16	AM	27,78	No Fatigue	66,67	High
17	AP	22	No Fatigue	76,67	High
18	AZ	14,85	No Fatigue	86,67	VeryHigh
19	F	23,58	No Fatigue	76	High
20	S	28,15	No Fatigue	60,67	High

used in Table 6, the results of calculations that have been carried out using the Cardiovascular Load method that there are 6 students, the value of the CVL percentage is > 30%, identifying that improvements are needed or there has been work fatigue experienced by refinery planning and optimization students, while when viewed from calculations using the NASA-TLX method that 4 student have an average score of 80-100 with a very high category. From the results of processing that has been carried out during observations and observations that can be analyzed.

Discussion

For further research, it is better when looking for questionnaire data to distribute the questionnaire directly in the form of paper sheets, not through Google form, because it is more effective. After all, the NASA-TLX scale is 0-100. If using Google Forms, the scale is less effective. It needs to be multiplied by 10 so that the scale follows the NASA-TLX scale. As suggestions for further research, it is necessary to research workload using the Work Load Analysis method to select the optimal number of respondents and measure performance to receive rest hours, the number of personnel, and the optimal workload.

Conclusion

The results of the comparison of the NASA-TLX and CVL methods are the results of calculations that have been carried out; there are NASA-TLX results that the average produced by four students has an average score of 80-100 with a very high category. The results of the calculation of the CVL percentage that six students have a percentage value of > 30% identify that improvement is needed or work fatigue has occurred. Judging from the results of the NASA-TLX and CVL methods, mental workload will greatly affect physical workload. CVL results are more dominant than the results of the NASA-TLX method, as seen from the average, which has a very high category. There are four students, while the CVL method only has six students who need improvement or experience fatigue.

Acknowledgment

We want to thank the committee of The 6th Borobudur International Symposium 2024 (Universitas Muhammadiyah Magelang) and Mrs. Tania AG, Ph.D (Chair of LPPM UM Cirebon) for the help and opportunity to attend this seminar and for her comments that significantly improved this manuscript and colleagues from the faculty Engineering of

UM Cirebon who provided insights and expertise that immensely helped this research. However, they may not agree with all interpretations/conclusions of this article. Lastly, I thank my family for their unconditional love and support.

References

1. Pasaribu, M.X.N.; Harlin, H.; Syofii, I. Analisis Kesulitan Penyelesaian Tugas Akhir Skripsi Pada Mahasiswa Program Studi Pendidikan Teknik Mesin Universtas Sriwijaya. *J. Pendidik. Tek. Mesin* **2016**, *3*.
2. Marhaendra, T.B.P. *Ergonomi Dinamika Beban Kerja*; 2022;
3. Chairunnisaa, S.; Ramadhany, N. Analisis Beban Kerja Mental Dengan Metode NASA-TLX Pada Karyawan Divisi Production and Maintenance Di PT. **2022**, 1–9.
4. Handika, F.S.; Yuslistyari, E.I.; Hidayatullah, M. Analisis Beban Kerja Fisik Dan Mental Operator Produksi Di Pd. Mitra Sari. *J. InTent* **2020**, *3*, 82–89.