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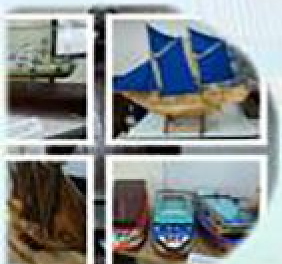

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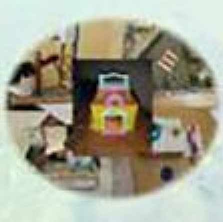

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Mental workload analysis of Industrial Engineering students using Subjective Workload Assessment Technique (SWAT)

Leonardo*, Elty Sarvia

Department of Industrial Engineering, Universitas Kristen Maranatha, Jl Prof. drg. Surya Sumantri, M.P.H. No 65, Bandung 40164, Indonesia

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ABSTRACT

Mental stress can stem from uncontrolled physical demands, environmental factors, and social situations. In academic environments, this stress often impacts student performance, notably during lecture activities. This study aims to analyze the mental workload experienced by the 2020 class of Industrial Engineering students at a private university. Its goal is to identify factors contributing to students' mental workload and propose suggestions to address these challenges. The Subjective Workload Assessment Technique (SWAT) was utilized to assess mental workload through respondent evaluations. Additionally, a Fishbone Diagram was employed to pinpoint factors leading to increased mental workload in students. Questionnaires were distributed to all students enrolled in at least 18 credits during the odd semester of 2022-2023. The findings indicate that students of the 2020 class experience mental burden during both class and practicum activities. Specifically, class activities accounted for 46.78% in the time dimension and 25.77% in the effort dimension, while practicum activities accounted for 55.34% in the time dimension and 20.39% in the effort dimension. Stress levels were recorded at 27.45% for class activities and 24.27% for practicum activities. The analysis identifies various stress-inducing factors in teaching and learning activities, including challenges in studying quiz and practicum materials, active participation in practicum activities, completion of practicum reports, and effective communication with practicum partners. To address these challenges, several recommendations are proposed, such as restructuring lecture schedules, equitable distribution of assignments and quizzes throughout the semester, fostering effective time management, aligning credit loads with individual capacities, among other strategies.

1. Introduction

Mental stress can arise due to uncontrolled physical demands, environmental factors, and social situations. According to data from [1], over 350 million people worldwide experience mental stress, ranking it as the 4th most prevalent disease globally. As reported in [2] on September 7, 2022, out of 3,901 students, only 24% (933 students) were symptom-free from mental stress. Meanwhile, 45% (1,766 students) experienced mild mental stress, 22% (861 students) experienced moderate mental stress, and 7% (267 students) reported severe mental stress. Students play a pivotal role in any university, especially those in the Industrial Engineering Study Program at X University, established in 1965 and having produced over 30,000 alumni contributing significantly to domestic and international development sectors. The student body encompasses diverse individuals, akin to the diversity inherent in human nature.

Through observations of Industrial Engineering students at University X, certain students frequently miss lectures, doze off during classes, feel uncomfortable on campus, and some have even changed majors or left the University. It is speculated that students pursuing degrees may bear an overwhelming workload that remains unexpressed. For instance, excessive tasks assigned by lecturers, congested lecture schedules resulting in fatigue and insufficient rest, discomfort in social interactions, or other stress-inducing factors might be contributing to students' mental stress.

Preliminary observations and random interviews suggest that semester 3 and semester 5 courses and credit loads tend to trigger students' mental stress. Therefore, this study will focus on analyzing the mental

*Corresponding author:
Email: leonardo575353@gmail.com

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workload of the 2020 class of Industrial Engineering students at University X, currently in their 5th semester.

The Subjective Workload Assessment Technique (SWAT) is a quantitative method to measure mental load. It involves respondents rating three workload dimensions, each with three points: time burden, mental effort burden, and psychological pressure burden [3]. The SWAT method's complexity involves generating a scale wherein participants rank 27 cards, each representing different combinations of the three dimensions, in order of perceived workload [4].

Previous studies utilizing the SWAT method have assessed employee mental workload [5]–[7], military environment operators [8], and pilots [9]. However, research specifically focusing on students' mental workload remains scarce. High workload demands and stress can significantly impact students' health-related behaviors [10].

The combination of physical and mental workloads determines the overall burden individuals experience, particularly prominent activities compared to others [11]. Being a student, the learning process constitutes a significant daily activity, and understanding the burden students face is crucial to prevent undesirable stress-related impacts [12], [13]. Addressing students' mental health issues is imperative [14], [15], especially for engineering students, to prevent negative perceptions of stress and mental health [16]. Elevated stress levels can detrimentally affect academic performance and retention in academic programs [17], while also posing risks of further mental health issues and physical illnesses [18].

As students, they bear the responsibility of executing tasks and engaging in the learning process, which can exert internal and external pressure [19]. Industrial engineering students, notably, face numerous assignments from courses and practicum tasks, often dominating their daily routines. Hence, assessing the mental burden among students during lectures becomes crucial. Some students might undertake tasks beyond their capacity, leading to mental stress—for instance, enrolling in the maximum number of credits despite busy schedules outside of college. This can result in course overlaps and increased stress. Addressing these concerns, this research endeavors to analyze the mental workload of Industrial Engineering students at University X, particularly those in their 5th semester, and identify factors contributing to their mental workload.

2. Material and method

The research methodology involved distributing questionnaires to all students from the Class of 2020 who were enrolled in a minimum of 18 credits, resulting in 20 respondents for this study. These students are currently engaged in both regular class courses and practical coursework known as practicum. To distinguish between these, the term "class activities" refers to regular courses, while "practicum" denotes courses requiring practical simulations and module-specific report submissions. Presently, it's identified that students from the Class of 2020 are actively participating in practicum sessions focused on Computer Simulation and Information Systems Design Analysis.

The distributed questionnaire comprises three parts: the Subjective Workload Assessment Technique (SWAT) card ranking questionnaire, the event scoring questionnaire, and the Fishbone Diagram Likert scale questionnaire. Once the necessary data is collected, subsequent steps involve data processing and analysis to formulate proposals addressing the issues identified in this study.

1. Subjective Workload Assessment Technique (SWAT) Data Processing

Data processing involves utilizing Dosbox 0.74 software on a computer or laptop. The gathered data from respondents will be input into the software to determine their scores. The steps involved in processing data using the subjective workload assessment technique (SWAT) through Dosbox 0.74 software are as follows:

a) Explanation of the SWAT method to the student respondents involved in this study, followed by sorting the 27 SWAT cards according to the perceived workload intensity during lectures, from lowest to highest.

b) Once the cards are sorted by respondents, the next stage involves scale development by prototyping the potential of each workload dimension. This prototype aids in obtaining the Kendall coefficient of concordance, determining the axiom test value.

c) The SWAT program processes the entered card measurements, producing rescaled outcomes.

d) Event Scoring: Each respondent provides their opinions regarding the workload dimensions experienced in each task.

e) Comparison of the workload dimension answers with the rescaled card sorting results, noting the number of scales listed in the program's processing outcomes.

2. Scale Development Data Processing

Scale development data is derived after entering the results of sorting the 27 SWAT cards by students into the Dosbox 0.74 software. The output of this scale development relies on the obtained Kendall coefficient. If Kendall's coefficient value is <0.75, it implies the sorted SWAT cards by students lack homogeneity, requiring the utilization of the Individual Scaling Solution method within the software for processing scale development data. Alternatively, if Kendall's coefficient value is ≥ 0.75, indicating homogeneity in the sorted SWAT cards by students, the Group Scaling Solution method within the software is used for scale development data processing, allowing the use of rescaled SWAT from all subjects or students combined.

3. Event Scoring

Following the scale development data processing, the rescaled SWAT data for each category, such as class activities and practicum activities, will be available. Event scoring then adjusts the weighting results of time, effort, and stress dimensions from the event scoring questionnaire with the rescaled SWAT on scale development to categorize each student's mental workload in class and practicum activities. As per Luximon and Goonetilleke [20], mental workload falls into three categories: low (final scale value of 0-40), moderate (final scale value of 41-60), and high (final scale value of 61-100).

4. Prototype of Class of 2020 Students

The Dosbox 0.74 software generates prototype outcomes after inputting the results of sorting 27 SWAT cards by students. The prototype showcases the percentage of time, effort, and stress dimensions within class activities and practicum categories. These prototype findings will be analyzed to adjust the mental workload category in class and practicum activities conducted by students, based on the event scoring results.

If the conversion value from the SWAT scale to the SWAT rating is less than 40, the subject can be deemed to have an optimal workload. Should the SWAT rating fall between 40 and 100, it indicates a high workload, signifying that, during that time, the subject cannot accommodate additional types of work [21]. Moreover, the fishbone diagram data is compiled to identify the factors contributing to the high mental load experienced by the 2020 students.

3. Results and discussions

The scale development data processing represents the outcome of Subjective Workload Assessment Technique (SWAT) data processing using Dosbox 0.74 software derived from the respondents' card sorting results. The scale development results are accessible within the group scale outcomes available in the Dosbox 0.74 software. Given the existence of two distinct categories, namely mental workload during class activities and practicum activities, the class of 2020 students yields two sets of scale development outcomes. If the Kendall coefficient value derived from each category's data is processed and found to be less than 0.75, it suggests that the arrangement of cards between objects is dissimilar or non-homogeneous, thereby necessitating the application of Individual Scaling Solution. Conversely, if the Kendall coefficient value from each category's data processing exceeds 0.75, it implies that the card arrangement between objects is relatively consistent or homogeneous, enabling the utilization of group-based processing or Group Scaling Solution.

Table 1 indicates the Kendall coefficient value post-prototyping. As the Kendall coefficient value in this category stands at 0.7299, falling below 0.75, it necessitates the utilization of the Individual Scaling Solution method. Tables 2 and 3, accessible in the attached page, showcase the outcomes of scale development derived from the Individual Scaling Solution method within the SWAT program.

Table 1.
Summary of Kendall's coefficient value

Mental Workload Category	Kendall Coefficient Value
Class Activities	0.7299
Laboratory Activities	0.6194

Table 2.
Scale development Class of 2020 during class activities

No	Card	Worload Combination			Rescaled												
		Time	Effort	Stress	1	2	3	4	5	6	7	8	9	10	,,,	,,,	20
1	N	1	1	1	0	0	0	0	0	0	0	0	4.6	0	0	0	0
2	B	1	1	2	8.1	3.8	14.3	9.7	8.2	9.9	16.4	14.4	33.8	15.8	3.8	3.8	22.3
3	W	1	1	3	28.3	7.7	19.3	26.8	8.4	10.4	23.2	16	53.4	28.9	7.7	7.7	21.7
4	F	1	2	1	7.9	11.5	15.1	14.9	8.7	10.1	17.8	18.7	30.4	15.9	11.5	11.5	13.8
5	J	1	2	2	15.9	15.4	29.4	24.6	16.9	20	34.2	33.2	59.6	31.7	15.4	15.4	36.1
6	C	1	2	3	36.2	19.2	34.4	41.7	17.1	20.5	41	34.7	79.2	44.8	19.2	19.2	35.5
7	X	1	3	1	27.8	23.1	30.1	24.4	21.5	20.2	33.3	23.8	29.8	28.6	23.1	23.1	26.3
8	S	1	3	2	35.8	26.9	44.4	34.1	29.7	30.1	49.7	38.3	59.1	44.4	26.9	26.9	48.6
9	M	1	3	3	56.1	30.8	49.4	51.2	29.9	30.6	56.5	39.8	78.7	57.5	30.8	30.8	48
10	U	2	1	1	32.8	34.6	34.2	13.2	53.2	34.7	17.6	39.9	0	23.2	34.6	34.6	28.4
11	G	2	1	2	40.8	38.5	48.5	22.9	61.3	44.6	34	54.3	29.3	38.9	38.5	38.5	50.7
12	Z	2	1	3	61	42.3	53.5	40	61.5	45.1	40.8	55.8	48.9	52	42.3	42.3	50.1
13	V	2	2	1	40.6	46.2	49.3	28.1	61.9	44.8	35.4	58.6	25.8	39	46.2	46.2	42.2
14	Q	2	2	2	48.7	50	63.6	37.8	70.1	54.7	51.8	73	55.1	54.8	50	50	64.5
15	ZZ	2	2	3	68.9	53.8	68.6	54.8	70.3	55.2	58.6	74.5	74.7	67.9	53.8	53.8	63.9
16	K	2	3	1	60.5	57.7	64.3	37.6	74.7	54.9	51	63.7	25.3	51.8	57.7	57.7	54.7
17	E	2	3	2	68.6	61.5	78.6	47.3	82.9	64.8	67.3	78.2	54.5	67.6	61.5	61.5	77
18	R	2	3	3	88.8	65.4	83.6	64.4	83.1	65.3	74.1	79.7	74.1	80.7	65.4	65.4	76.4
19	H	3	1	1	43.9	69.2	50.6	48.8	70.1	69.4	43.5	60.2	25.3	42.5	69.2	69.2	51.4
20	P	3	1	2	52	73.1	64.9	58.5	78.3	79.3	59.9	74.6	54.6	58.3	73.1	73.1	73.7
21	D	3	1	3	72.2	76.9	69.9	75.6	78.5	79.8	66.7	76.2	74.2	71.4	76.9	76.9	73
22	Y	3	2	1	51.8	80.8	65.7	63.7	78.8	79.5	61.3	78.9	51.1	58.4	80.8	80.8	65.2
23	A	3	2	2	59.9	84.6	80	73.4	87	89.4	77.7	93.4	80.4	74.1	84.6	84.6	87.5
24	O	3	2	3	80.1	88.5	85	90.5	87.2	89.9	84.5	94.9	100	87.3	88.5	88.5	86.9
25	L	3	3	1	71.7	92.3	80.7	73.2	91.6	89.6	76.8	84	50.6	71.1	92.3	92.3	77.7
26	T	3	3	2	79.8	96.2	95	83	99.8	99.5	93.2	98.5	79.8	86.9	96.2	96.2	100
27	I	3	3	3	100	100	100	100	100	100	100	100	99.5	100	100	100	82.3

Table 3.
Scale development during practicum activities

No	Card	Worload Combination			Rescaled												
		Time	Effort	Stress	1	2	3	4	5	6	7	8	9	10	,,,	,,,	20
1	N	1	1	1	0	0	0	0	0	0	0	0	19.6	0	0	0	0
2	B	1	1	2	8.1	3.8	14.3	9.7	8.2	12.9	16.4	14.4	30.3	11.9	3.8	3.8	22.3
3	W	1	1	3	28.3	7.7	19.3	26.8	8.4	9.6	23.2	16	97	21.7	7.7	7.7	21.7
4	F	1	2	1	7.9	11.5	15.1	14.9	8.7	3.9	17.8	18.7	19.2	20.9	11.5	11.5	13.8
5	J	1	2	2	15.9	15.4	29.4	24.6	16.9	16.8	34.2	33.2	29.8	32.8	15.4	15.4	36.1
6	C	1	2	3	36.2	19.2	34.4	41.7	17.1	13.5	41	34.7	96.6	42.6	19.2	19.2	35.5
7	X	1	3	1	27.8	23.1	30.1	24.4	21.5	19	33.3	23.8	13.5	24.8	23.1	23.1	26.3
8	S	1	3	2	35.8	26.9	44.4	34.1	29.7	31.9	49.7	38.3	24.1	36.6	26.9	26.9	48.6
9	M	1	3	3	56.1	30.8	49.4	51.2	29.9	28.6	56.5	39.8	90.8	46.5	30.8	30.8	48
10	U	2	1	1	32.8	34.6	34.2	13.2	53.2	34.1	17.6	39.9	22.6	34.9	34.6	34.6	28.4
11	G	2	1	2	40.8	38.5	48.5	22.9	61.3	47	34	54.3	33.3	46.8	38.5	38.5	50.7
12	Z	2	1	3	61	42.3	53.5	40	61.5	43.7	40.8	55.8	100	56.7	42.3	42.3	50.1
13	V	2	2	1	40.6	46.2	49.3	28.1	61.9	37.9	35.4	58.6	22.2	55.9	46.2	46.2	42.2
14	Q	2	2	2	48.7	50	63.6	37.8	70.1	50.9	51.8	73	32.8	67.7	50	50	64.5
15	ZZ	2	2	3	68.9	53.8	68.6	54.8	70.3	47.6	58.6	74.5	99.6	77.6	53.8	53.8	63.9
16	K	2	3	1	60.5	57.7	64.3	37.6	74.7	53	51	63.7	16.5	59.7	57.7	57.7	54.7
17	E	2	3	2	68.6	61.5	78.6	47.3	82.9	65.9	67.3	78.2	27.1	71.6	61.5	61.5	77
18	R	2	3	3	88.8	65.4	83.6	64.4	83.1	62.7	74.1	79.7	93.9	81.4	65.4	65.4	76.4
19	H	3	1	1	43.9	69.2	50.6	48.8	70.1	68.1	43.5	60.2	6.1	53.5	69.2	69.2	51.4
20	P	3	1	2	52	73.1	64.9	58.5	78.3	81	59.9	74.6	16.8	65.4	73.1	73.1	73.7
21	D	3	1	3	72.2	76.9	69.9	75.6	78.5	77.8	66.7	76.2	83.5	75.2	76.9	76.9	73
22	Y	3	2	1	51.8	80.8	65.7	63.7	78.8	72	61.3	78.9	5.7	74.4	80.8	80.8	65.2
23	A	3	2	2	59.9	84.6	80	73.4	87	84.9	77.7	93.4	16.3	86.3	84.6	84.6	87.5
24	O	3	2	3	80.1	88.5	85	90.5	87.2	81.6	84.5	94.9	83.1	96.1	88.5	88.5	86.9
25	L	3	3	1	71.7	92.3	80.7	73.2	91.6	87.1	76.8	84	0	78.3	92.3	92.3	77.7
26	T	3	3	2	79.8	96.2	95	83	99.8	100	93.2	98.5	76.3	90.2	96.2	96.2	100
27	I	3	3	3	100	100	100	100	100	96.7	100	100	81.2	100	100	100	99.4

Table 4.
Event scoring during class activities

No	Activities	Respondent 1					Respondent 2				
		T	E	S	SWAT Rescaled	Mental Load Category	T	E	S	SWAT Rescaled	Mental Load Category
1	Studying course material	2	2	1	40.6	Low	1	2	3	19.2	Low
2	Follow the lecture	2	2	2	48.7	Moderate	2	2	2	46.2	Currently
3	Carry out a task	3	1	2	52	Moderate	2	1	3	42.3	Currently
4	Study quiz material	2	1	2	40.8	Low	3	1	1	69.2	High
5	Work on the quiz	3	2	2	59.9	Moderate	3	2	2	84.6	High
6	Communication between friends	1	2	2	15.9	Low	2	1	1	34.6	Low

Table 5.
Summary of event scoring during class activities

Activities	Mental Load Category		
	Low	Moderate	High
Studying course material	11	8	1
Follow the lecture	6	7	7
Carry out a task	4	8	8
Study quiz material	5	5	10
Work on the quiz	3	0	17
Communication between friends	7	2	11

Table 6.
Summary of event scoring during practicum activities

Activities	Mental Load Category		
	Low	Moderate	High
Studying course material	1	7	12
Follow the lecture	3	5	12
Carry out a task	2	5	13
Study quiz material	4	11	5
Work on the quiz	2	10	8
Communication between friends	2	7	11

These scale development results aim to align with the SWAT rescale score outcomes from event scoring.

An example of how to complete Table 4, visible in the attached page, is outlined as follows:

1. Respondent 1, engaged in class activities, assigns weightings to the time, effort, and stress dimensions for the activity of studying course material—specifically, 2 for the time dimension, 2 for the effort dimension, and 1 for the stress dimension.
2. Subsequently, these dimension weightings of time, effort, and stress are calibrated against the rescaled SWAT values found in Table 2 for each respective respondent.
3. Referring to Table 2, the rescaled SWAT value for the first respondent, with a dimension weighting of 2 for time, 2 for effort, and 1 for stress, is 40.6.

After obtaining the rescaled SWAT values resulting from processing scale development data in each category, these values will be aligned with the weighted scores derived from the event scoring questionnaire, part 2, based on the time, effort, and stress factors provided by each student concerning activities conducted within class and practicum settings. These determinations establish mental load categorization: a SWAT value below 40 signifies a low mental load category, while values between 41-60 indicate a moderate mental load category. A SWAT value between 61-100 indicates a high mental load category. Tables 5 and 6 outline the summarized results of event scoring for both class and practicum activities.

Subsequently, the sorting of 27 SWAT cards into Dosbox 0.74 software for prototype processing is conducted. Table 7 and 8 display the processed prototype data for the Class of 2020 students engaged in both class and practicum activities using Dosbox 0.74 software. These outcomes include the assigned importance values for each dimension combination. Prototype processing aims to determine the proportion of the three dimensions: time, effort, and stress (see Table 9). These outcomes will be analyzed to identify the factors contributing to high mental load among students.

The time dimension significantly impacts student workload during class activities, while the stress dimension holds considerable influence in these activities. Conversely, the effort dimension exerts the least influence on the workload during class activities.

In practicum activities, the time dimension remains a significant factor affecting student workload. Similarly, the stress dimension holds considerable influence during these activities, while the effort dimension continues to have the least impact on workload.

The Likert scale is processed using the TxPn method, where T = Total number of respondents who choose and Pn = Likert score number options. Example of calculation on question 3 for the class of 2020 students:

- Respondents who chose very little effect: 1 x 1 = 1
- Respondents who chose no effect: 2 x 3 = 6
- Respondents who chose quite influential: 3 x 5 = 15
- Respondents who chose influential: 4 x 9 = 36
- Respondents who chose very influential: 5 x 2 = 10
- The total number generated is 68

After that, look for the interval value to determine the category of each question with the following conditions:

- - Interval = 100 / Number of scores (Likert)
- = 100 / 5
- = 20 (From 0 - 100)

The following is the score interpretation criteria based on the interval, namely the value 0% - 19.99% = Very little effect; 20% - 39.99% = No effect; 40% - 59.99% = Moderately influential; 60% - 79.99% = Influential; 80% - 100% = Very influential. Table 10 shows the results of the questionnaire distributed to each respondent to find out the percentage of each influence that causes the mental load that exists in the 2020 class of students. The factors that cause high mental will be made into a Fishbone Diagram. Figure A1 (see Appendices) is a Fishbone Diagram of the factors causing high mental load in university students.

Figure 1 compares the mental load analysis results for 2020 students during class and practicum activities. It reveals that the dimension with the most significant contribution to the mental workload of students in the Class of 2020 within the Industrial Engineering Study Program at X University is the time dimension, indicating high work time pressure. Meanwhile, the stress dimension (psychological pressure load) and effort pressure (mental effort load) remain at optimal levels.

Table 7.
Prototype of class of students during class activities

Respondent	Workload Combination						Prototype
	TES	TSE	ETS	EST	SET	STE	
1	0.77	0.76	0.66	0.61	0.56	0.60	T
2	1	0.96	0.6	0.43	0.3	0.43	T
3	0.9	0.86	0.68	0.58	0.48	0.55	T
4	0.9	0.9	0.61	0.52	0.53	0.63	T
5	0.86	0.84	0.49	0.35	0.29	0.41	T
6	1	0.96	0.6	0.42	0.31	0.44	T
7	0.87	0.87	0.72	0.66	0.64	0.69	T
8	0.88	0.88	0.52	0.4	0.42	0.54	T
9	0.49	0.58	0.5	0.59	0.84	0.84	S
10	0.85	0.84	0.75	0.71	0.67	0.7	T
11	1	0.96	0.6	0.43	0.3	0.43	T
12	0.7	0.72	0.49	0.43	0.46	0.54	T
13	0.43	0.6	0.3	0.43	0.96	1	S
14	0.29	0.36	0.11	0.13	0.35	0.41	S
15	0.79	0.76	0.5	0.37	0.29	0.39	T
16	0.83	0.82	0.75	0.71	0.69	0.72	T
17	0.78	0.79	0.73	0.72	0.73	0.74	T
18	0.75	0.74	0.65	0.61	0.58	0.61	T
19	1	0.96	0.6	0.43	0.3	0.43	T
20	0.87	0.86	0.63	0.54	0.49	0.57	T

Table 8.
Prototype of class of students during practicum activities

Respondent	Workload Combination						Prototype
	TES	TSE	ETS	EST	SET	STE	
1	0.77	0.76	0.66	0.61	0.56	0.6	T
2	1	0.96	0.6	0.43	0.3	0.43	T
3	0.9	0.86	0.68	0.58	0.48	0.55	T
4	0.9	0.9	0.61	0.52	0.53	0.63	T
5	0.86	0.84	0.49	0.35	0.29	0.41	T
6	1	0.96	0.6	0.42	0.29	0.43	T
7	0.87	0.87	0.72	0.66	0.64	0.69	T
8	0.88	0.88	0.52	0.40	0.42	0.54	T
9	0.22	0.35	0.32	0.48	0.88	0.85	S
10	0.86	0.85	0.63	0.54	0.51	0.59	T
11	1	0.96	0.6	0.43	0.3	0.43	T
12	0.78	0.69	0.51	0.33	0.08	0.17	T
13	0.36	0.25	0.23	0.07	0.26	0.21	S
14	0.28	0.44	0.09	0.19	0.67	0.73	S
15	0.12	0.12	0.03	0.01	0.01	0.04	T
16	0.83	0.82	0.75	0.71	0.69	0.72	T
17	0.78	0.79	0.73	0.72	0.73	0.74	T
18	0.75	0.74	0.65	0.61	0.58	0.61	T
19	1	0.96	0.6	0.43	0.3	0.43	T
20	0.87	0.86	0.63	0.54	0.49	0.57	T

Table 8.
Percentage of prototype dimensions

Dimension Factor	Class Activities	Laboratory Activites
Time	46.78%	55.34%
Effort	25.77%	20.39%
Stress	27.45%	24.27%

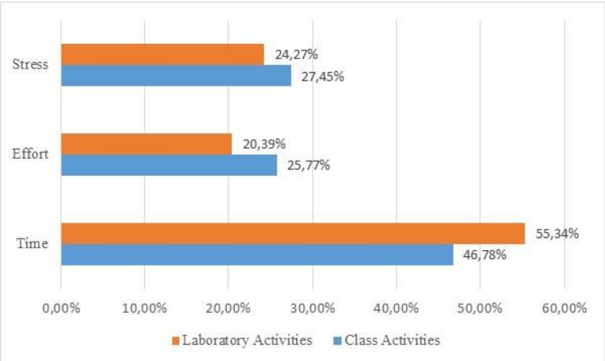

Figure 1. Time, Effort, and Stress of the Class of 2020

The primary factor influencing students in the Class of 2020 in the Industrial Engineering Study Program at University X is the time dimension. The demanding course load necessitates rapid completion of both practicum reports and weekly coursework. Students in their fifth semester have minimal free time during lectures due to the workload.

Regarding the most significant factor contributing to students' mental burden during teaching and learning activities in class, it's apparent that much of their time is consumed studying quiz materials, taking quizzes, and socializing with peers, leaving minimal free time. Social interactions within the lecture environment might further diminish their focus on academic responsibilities.

In the case of the highest mental load contributors during practicum activities, students invest substantial time studying practicum materials, engaging in practicum tasks, compiling practicum reports, and coordinating with partners. The 2020 class simultaneously undertakes two practicums—Computer Simulation and Information Systems Design Analysis (APSI)—in a single semester. Notably, the report deadlines for the Computer Simulation practicum occur biweekly per module, while APSI reports are due weekly. Consequently, there are weeks where report submissions for both practicums coincide, creating a tight schedule for students.

Moreover, during weekdays, students have various commitments like lectures and mandatory assistance activities. Saturdays remain non-conducive for assistance due to limited practicum supervisor schedules. As a result, students encounter intense schedules throughout the weekdays, further compounded by the challenging nature of the Computer Simulation practicum, necessitating proficient coding skills. Errors in coding result in program malfunction or erroneous output, demanding exhaustive debugging processes, contributing significantly to time consumption.

The case study questions within the Computer Simulation practicum are intricate and time-consuming to comprehend. Students find these questions intricate to locate within the context, necessitating meticulous scrutiny and prolonged comprehension efforts.

While the time dimension reflects a high workload due to scheduling conflicts, multiple obligations, and complex case study questions, both the stress and effort dimensions remain moderately influential. The stress dimension embodies confusion and frustration affecting task performance, usually associated with engineering programs. However, for 2020 students, stress levels remain optimal during both class and practicum activities.

Table 10
Results of Likert scale data processing

No	Question	(1)	(2)	(3)	(4)	(5)	100	Percentage	Category
1	The Effect of Practicum Activities on Student Mental Loads?				6	14	94	94%	Very influential
2	Effect of Sleeping Hours on Student Mental Load?		1	2	6	11	87	87%	Very influential
3	The influence of the lecturer on the mental burden of students?	1	3	5	9	2	68	0.68	Influential
4	The Effect of College Assignments on Student Mental Burden?	1		4	10	5	78	0.78	Influential
5	Effect of lecture schedule on student mental burdens?		3	5	8	4	73	73%	Influential
6	The Effect of Friendship on Student Mental Loads?		3	5	4	8	77	77%	Influential
7	Effect of lecture facilities on student mental burdens?	2	6	7	2	3	58	0.58	Quite influential
8	The influence of the room condition on the mental burden of students?	2	6	3	5	4	63	0.63	Influential
9	The Effect of Learning Systems on Student Mental Loads?		3	6	7	4	72	72%	Influential
10	The Effect of Learning Materials given by the lecturer on the mental burden of students?			6	6	8	82	82%	Very influential

Note: (1) Very influential, (2) No effect, (3) Quite influential, (4) Quite fluential, (5) Very fluential

Although the effort dimension holds the least influence among the three dimensions, it stands in the optimal category, constituting 25.77% for class activities and 20.39% for practicum activities. Despite being the least influential, learning quiz materials, undertaking quizzes, and engaging with peers demand substantial effort, concentration, and attention from students.

From the findings depicted in the fishbone diagram in Figure A1 (see Appendices) the identified factors contributing to the mental load among the Class of 2020 students include:

1. Man
• Lack of cooperation among practicum partners leads some students to work individually, consuming more time.
   • Unsupportive social environments compel students to work alone, lacking avenues for discussion.
   • Inflexible schedules of practicum supervisors (Laboratory Assistants), often occupied with other commitments, limit onsite discussions, and hamper online assistance.
2. Material
   • Complexity in understanding practical materials, particularly the intricate case studies within the computer simulation practicum, necessitates substantial time for comprehension due to interconnected storylines and numerous entities.
   • The need to study quiz materials for various courses with impending quizzes adds to the workload.
3. Environment
   No grievances regarding classroom or laboratory conditions, indicating satisfactory infrastructure.
4. Method
   • Overlapping schedules for completing activities related to the two types of practicums pose challenges.
   • Limited sleep schedules due to the volume of assignments from both lectures and practicums.
   • Hectic lecture schedules from Monday to Wednesday, while Thursdays and Fridays relatively have fewer commitments. Fridays, earmarked for practicum assistance, demand students to hasten report submissions.
   • Quiz schedules during lectures and practicums do not align, leading to either simultaneous ease or excessive workload.
5. Machine
   • Inadequate support from laptop processors during practicum tasks due to limitations in the student version of the program. The program's limitations, such as the entity threshold, often lead to program crashes if system specifications are not met, necessitating repeated coding.
   • Limited access to computer laboratories during practicum and exams, forcing students to rely on their laptops with restricted simulation program versions for report assignments.

4. Conclusions

The Class of 2020 students are engaged in two activity categories: class and practicum. In class activities, the percentages for each dimension were as follows: time 46.78%, effort 25.77%, and stress 27.45%. During practicum activities, the percentages for each dimension were time 55.34%, effort 20.39%, and stress 24.27%. These percentages indicate that the time dimension significantly contributes to both class and practicum activities, leaving students with minimal free time for other pursuits. Meanwhile, the effort and stress dimensions remain within the optimal range.

The proposed solutions are categorized into suggestions for the Industrial Engineering study program at University X and recommendations specifically for Industrial Engineering students at University X. These suggestions aim to alleviate time pressures that lead to heightened mental workloads. First, restructure the lecture timetable or class hours by designing academic schedules that evenly distribute coursework and quizzes across the weekdays, avoiding congestion on specific days. Second, revise the laboratory assignment collection schedule to prevent overlaps and simplify the case study assignments for computer simulations. This can be achieved by incorporating additional visuals like Entity Flow Diagrams (EFD) to enhance comprehension and reduce time. Further, providing access to computers with licensed programs in the laboratory can prevent coding errors and repetitions for students.

Proposals for future research include measuring the mental workload among 3rd-semester students, comparing mental workload categories across different semesters for the same respondents or different ones, and evaluating the mental workload among students in various study programs within the Faculty of Engineering.

Declaration statement

Leonardo: **Conceptualization, Methodology, Supervision, Software, Writing - Original Draft**. Elty Sarvia: **Conceptualization, Methodology, Writing - Review & Editing**.

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Data availability statement

The authors confirm that the data supporting the findings of this study are available within the article or its supplementary materials.

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Appendices

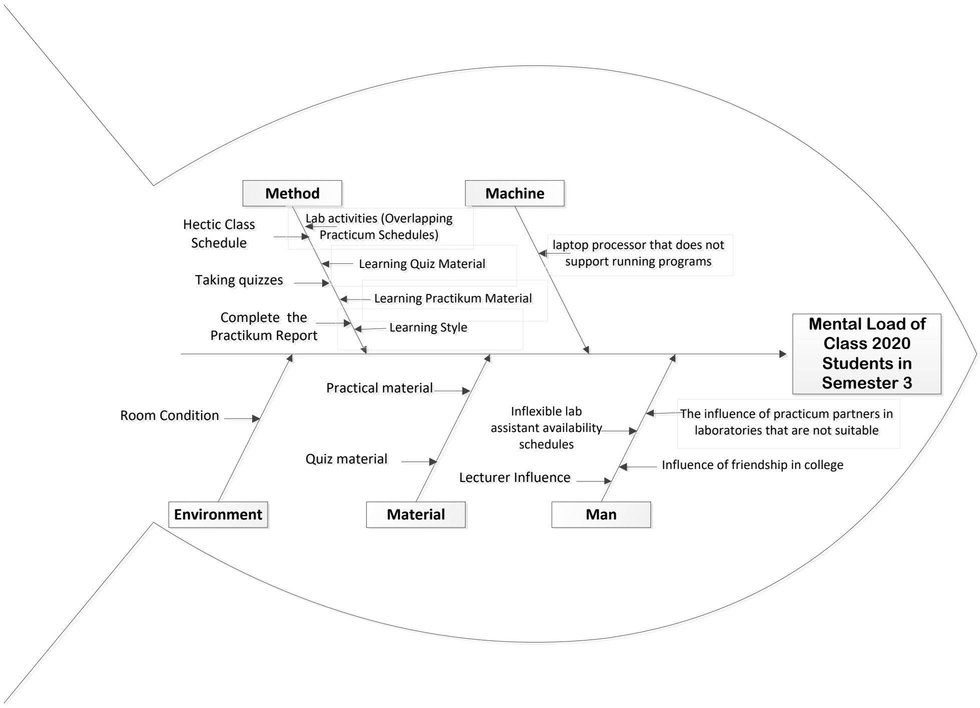

Figure A1. Fishbone diagram

UNIVERSITAS KRISTEN MARANATHA
Fakultas Teknik
Program Sarjana Teknik Industri

Jl. Prof. drg. Surya Sumantri, M.P.H. No. 65
Bandung - 40164, Jawa Barat, Indonesia
Telp: +62 22-201 2186 / 200 3450, ext. 1262 / 1263
Fax: +62 22-201 7622
Email: ti@eng.maranatha.edu
www.maranatha.edu

S U R A T T U G A S

Nomor : 058/PRODI.TI/UKM/Surat Tugas/X/2023

Yang bertandatangan di bawah ini :

Nama : Christina, S.T., M.T.
Jabatan : Ketua Program Teknik Industri
Universitas Kristen Maranatha Bandung

Dengan ini menerangkan bahwa :

NIK/NRP	Nama Dosen/Mahasiswa	Keterangan
1823028	Leonardo	Penulis Pertama (Mahasiswa)
230568	Elty Sarvia, S.T., M.T.	Penulis Kedua (Dosen)

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Bandung, 25 Oktober 2023
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Christina, S.T., M.T.