Measurement of psychological impact of industrial engineering students in fulfil of online learning outcomes using NASA-TLX method

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Abstract. COVID-19 had a serious impact on the education sector in Indonesia, one of them is the application of online learning activities as a substitute for learning activities in the classroom. Viewed from the perspective of students, online learning is a new method and is not yet commonly used in universities including Sultan Ageng Tirtayasa University. So students still need time to adapt to the existing system. Each activity certainly causes consequences of workload, as well as its online learning activities conducted by students majoring in Industrial Engineering Untirta. This study will measure the psychological impact in the form of mental workload experienced by students majoring in Industrial Engineering Untirta in meeting online learning outcomes using the National Aeronautics and Space Administration Task Load Index (NASA-TLX) method. The online learning process carried out by Industrial Engineering students of Sultan Ageng Tirtayasa University has a psychological impact in the form of mental workload on these students. The results showed that 63.21% of students experienced mental workloads with moderate classification, 22.97% of students had workloads with heavy classifications while the rest experienced workloads with light classifications (13.51%). The most dominant indicators are Mental Demand, Temporal Demand, and Frustration Level.

1. Introduction
Corona Virus Disease - 2019 (COVID-19) which surrounded Indonesia seems unable to be muted. Its spread is massive and relatively fast makes people panic and fear. Everyone is forced to stay at home to break the chain of transmission of COVID-19. Mass agendas were omitted because COVID-19 also the term work from home (WFH) became popular. Not only that, but COVID-19 also had a serious impact on the education sector in Indonesia. One of them is the application of online learning activities as a substitute for learning activities in the classroom.

Since the beginning of March Industrial Engineering students at Untirta has been carrying out online learning activities, not only the process of delivering the material, even the Midterm Examination was also conducted online. This is due to the Government's policy on learning from home related to the existence of the COVID pandemic 19. However, to date, it has not been known how much psychological impact experienced by students in carrying out these online learning activities. Other paragraphs are indented.

Online learning is learning done face-to-face through the available platforms. The difference lies in the technical delivery of the material alone, while the assessment indicators and achievements to be achieved remain the same as ordinary learning activities. Taken from the perspective of students, online learning is a new method and is not yet commonly used in universities, including at the
University of Sultan Ageng Tirtayasa. There are several platforms used in the online learning process, including SPADA, ZOOM, SIAKAD, Whatsapp group, etc.

Each activity certainly causes consequences of workload, as well as its online learning activities conducted by students majoring in Industrial Engineering Untirta. One psychological impact caused is in the form of mental workload felt by students. The mental workload can be seen as an external independent variable in task demands, and mental workload is defined as an interaction between task demands and human capabilities or resources. Analysis of workloads can be useful in providing information about job demands by worker limitations, it can also be used for system optimization.

Online learning has several components involved, including learning content, hardware in the form of computer devices, interaction strategies, network infrastructure, and software used. Activities in this activity are more dominant involving mental processes because in this activity information processing takes place. This mental process includes the receipt of stimulus from the work system, the process of converting the stimulus into meaningful information, to making decisions that are in line with the information obtained (Iridiastadi & Yassierli, 2014).

The concept of mental workload leads to attentional demands experienced while performing cognitive tasks (O'Donnell in Matthews, et al., 2000). The concept of mental workload has become increasingly important since the development of semi-automatic and computerized technology. This condition makes humans must have the mental ability to process all information received, both information on manufacturing tasks and administrative tasks.

Although there is no specific definition of mental workload, the universally mental workload is based on the difference in the number of resources owned by the number of demands of work to be done (Sanders & McCormick, 1992). Also added by Haga, et al. (2002), Hacker (2005) and Attwood, et al. (2007) that mental workload is the degree of process capacity incurred during displaying tasks, and the concept of mental workload arises because of the information process. The information process involves the perception, interpretation, and process of information conveyed by sensory organs. From all these opinions it appears that mental workload exists in every type of work that results from the information process. There are various aspects that people understand when asked about mental workloads, including the amount of work that is a burden, the pressure of time, the level of effort, the success of meeting demands, the psychological and physiological consequences of the task. Besides mental workload is often associated with task difficulties. So the assessment of workload made by one person may reflect his assessment of the difficulty of the task, while others may reflect it as the level of effort that must be expended.

One method that can be used to measure mental workload is the National Aeronautics and Space Administration Task Load Index (NASA-TLX). This method is used to analyze the mental workload faced by someone who has to carry out various activities and work. This method was developed by Sandra G. Hart of NASA Ames Research Center and Lowell E. Staveland of San Jose State University in 1981. This method was developed based on the need for subjective measurements consisting of a scale of Nine factors (task difficulty, time pressure, type of activity, physical effort, mental effort, performance, frustration, stress, and fatigue). The nine factors are simplified into six, namely the needs of Mental Demand (MD), Physical Demand (PD), Temporal Demand (TD), Performance (P), and Frustration Level (FR). Therefore in this study, the measurement of mental workload will use the NASA-TLX method.

This study will measure the psychological impact experienced by industrial engineering students of the Sultan Ageng Tirtayasa University in online learning activities. This psychological impact can be seen from the mental workload score generated from the NASA-TLX questionnaire.

2. Methodology

In this study, a survey will be conducted on Industrial Engineering students of the Sultan Ageng Tirtayasa University about online learning activities that are being carried out. From the survey results, it can be seen the frequency of online learning and the platforms most widely used in online learning activities. While the psychological impact will be measured in the form of mental workload scores of
Industrial Engineering students in meeting online learning outcomes. The method used for measuring mental workload is NASA-TLX. Some steps in this research are explained below.

2.1. Preliminary
At this stage the preparation of the questionnaire will be used, there are some changes, especially in the questionnaire distribution technique. The questionnaire used was in the form of a NASA-TLX questionnaire that had been converted into a google form to facilitate the process of distributing questionnaires in the Covid-19 pandemic conditions. There are 2 groups of questions. The first group is the respondent's identity and the platform used in online learning activities, while the second group consisted of questions from the NASA-TLX Questionnaire. NASA-TLX questionnaire contains questions to weight 15 pairwise comparisons and gives a rating of 0 to 100 for each NASA-TLX indicator.

2.2. Data Collection
The distribution of questionnaires was carried out online through a network of social media groups found among Industrial Engineering students of Sultan Ageng Tirtayasa University. 74 respondents sent responses to the questionnaire that had been distributed and all of the data was then used for data processing in this study. Data collected in the form of respondent characteristic data include age, gender, and level of the student. Also, the main data in the form of weighting and rating of the indicators contained in the NASA-TLX questionnaire.

2.3. Data Processing
2.3.1. Weighting
In this section, respondents are asked to choose one of two indicators that are felt to be more dominant causing mental workload on these activities. The NASA-TLX questionnaire was given in the form of pair comparisons consisting of 15 pair comparisons. From this questionnaire, the number of tally from each indicator felt was the most influential. This tally amount will then be the weight for each mental load indicator.

2.3.2. Rating
In this section, respondents were asked to give a rating of the six indicators of mental workload. The rating given is subjective depending on the respondent's perception and the rating scale ranges from 0 to 100.

2.3.3. Score Calculation
To get a NASA-TLX mental workload score, the weights and ratings for each indicator are multiplied and then added up and divided by 15 (number of pairwise comparisons). as contained in the following formula

$$Skor = \frac{\sum(\text{weight} \times \text{rating})}{15}$$  \hspace{1cm} (1)

2.3.4. Mental Workload Classification.
Based on the results obtained, an interpretation of the score results will be based on the following explanation (Hart and Staveland, 1981):
- a. $> 80$ indicates a heavy workload
- b. $50 - 80$ states the workload is moderate
- c. $< 50$ stated the workload was rather light
3. Results and Discussion

3.1. Data characteristics respondents

In this study, all respondents were students of the Department of Industrial Engineering - Sultan Ageng Tirtayasa University who filled out the questionnaire online. The results of data collection 74 respondents are consisting of 35 men and 39 women who have an age range between 18 to 22 years. The percentage of respondents by gender can be seen in Figure 1, while the distribution of respondents by the level of study can be seen in Table 1.

The most widely used platform is the Zoom Application used by 69 respondents (93%), as many as 47 respondents stated using the Spada application and Google Classroom as many as 10 respondents. The Zoom application is an application used by almost all respondents, but respondents use more than one application in implementing online learning.

![Figure 1. The percentage of respondents by gender](image)

Table 1. Distribution of respondents by the level of study

| No | Gender | 2016 | 2017 | 2018 | 2019 |
|----|--------|------|------|------|------|
| 1  | Man    | 7    | 10   | 13   | 5    |
| 2  | Woman  | 3    | 18   | 12   | 6    |
|    | Total  | 10   | 28   | 25   | 11   |

From the results of data collection, it is known that respondents experienced several obstacles in implementing online learning. These complaints consisted of 72.8% of respondents experiencing complaints related to devices and signals, 2.8% of physical complaints, and 25.7% of psychological complaints in the form of difficulties in focusing and concentration during the online learning process.

3.2 Mental Workload Score

Based on the results of weighting and rating (Table 2) that has been done based on the results of the NASA TLX questionnaire, a mental workload score is felt by Industrial Engineering students during the online learning process. Based on the calculations performed, it is known that there are 10 students (13.51%) who have light mental workloads, 47 students (63.51%) who have moderate workloads, and 17 students (22.98%) students who have heavy workloads. While the average score of all respondents was 67.69 with a moderate mental workload classification.
Figure 2 shows that 10 students feel a mental workload with a light classification, this is influenced by the frequency of students doing online learning in one week. Respondents who experienced a light mental workload classification had a frequency of online learning 5 to 8 times per week and most complained about complaints related to technical matters such as poor signal, quota usage costs, and matters related to online learning tools. The mental workload was the most experienced by respondents, as many as 47 students (63.51%), they have the frequency of doing online learning more often than those included in the classification of mild mental workloads of 8 to 25 times per week. Whereas for respondents who experienced mental workloads with heavy classifications totaling 12 people (22.97%) had the frequency of doing online learning more frequently than respondents who experienced moderate mental workloads.

Based on NASA TLX data processing, it can be seen as the most dominant indicator in the process of mental workload, as shown in Table 2 below.

| Respondent Number | Score | Respondent Number | Score | Respondent Number | Score | Respondent Number | Score | Respondent Number | Score |
|-------------------|-------|-------------------|-------|-------------------|-------|-------------------|-------|-------------------|-------|
| 1                 | 82.8  | 18                | 87.6  | 35                | 79    | 52                | 66.3  | 69                | 76    |
| 2                 | 58    | 19                | 65.3  | 36                | 74.26 | 53                | 68    | 70                | 20.3  |
| 3                 | 80.67 | 20                | 78    | 37                | 81.9  | 54                | 42    | 71                | 52.6  |
| 4                 | 79.73 | 21                | 87.3  | 38                | 67.4  | 55                | 62.3  | 72                | 84    |
| 5                 | 78.40 | 22                | 90.0  | 39                | 73.6  | 56                | 74    | 73                | 23.9  |
| 6                 | 68.67 | 23                | 62.3  | 40                | 82    | 57                | 47.3  | 74                | 80.3  |
| 7                 | 75.3  | 24                | 50    | 41                | 30.3  | 58                | 62.6  |
| 8                 | 40    | 25                | 64.3  | 42                | 62.6  | 59                | 80    |
| 9                 | 81.60 | 26                | 77    | 43                | 58    | 60                | 84.2  |
| 10                | 84.00 | 27                | 74.86 | 44                | 69.0  | 61                | 89.9  |
| 11                | 76.00 | 28                | 68    | 45                | 84    | 62                | 77.3  |
| 12                | 78.00 | 29                | 60.3  | 46                | 45.3  | 63                | 60    |
| 13                | 56.6  | 30                | 80.3  | 47                | 38.6  | 64                | 42.6  |
| 14                | 62.3  | 31                | 59    | 48                | 18    | 65                | 77    |
| 15                | 74    | 32                | 70    | 49                | 64    | 66                | 78.3  |
| 16                | 73.3  | 33                | 74.6  | 50                | 79.7  | 67                | 74    |
| 17                | 69.6  | 34                | 67.3  | 51                | 82.4  | 68                | 61    |

Mental Demand (MD) and Temporal Demand (TD) are the biggest indicators, each at 20%. The mental demand indicator shows how much mental and perceptual activity (such as seeing, remembering, searching) needed in doing work. The MD aspect is dominant because the online learning process is related to the activity of seeing, and understanding the material delivered by the
teaching lecturer. Whereas Temporal Demand is a very important dimension in completing a job. According to Sandra G Hart dan Lowell E Staveland (1988), Temporal Demand is a major factor in measuring workload and also has a high relationship with other dimensions. High temporal demand on students indicates that the pressure felt by students to complete their workload is related to time pressure. Due to the time online learning by using the application used there is a time limit so that sometimes the lecturer's explanation is only partially delivered.

The third dominant aspect is frustration level (FR) and effort (EF) of 19%, indicating that students in completing their work feel anxiety, stress, or severe stress. Because at the time of online learning applications that consume a lot of internet quota also become obstacles so that in the frustration aspect (FR) students do not feel satisfied. Because the learning process is done online, the concentration is not as good as learning in the classroom, also the home environment is sometimes not conducive, so students will feel effort (EF) or heavy mental work to complete the assignments.

The online learning process carried out is one of the forms of information processing in humans. in this activity, there is an interaction between humans and machines. One approach that can be used to understand human-machine interaction is to model how the human brain processes information. there are at least 3 major stages in processing information (Wickens et al. 2004). namely (1) understanding the information provided by the environment (2) processing the information at a higher level and (3) responding to that information. when online learning activities take place, students must be able to direct concentration on the lecture material that is being delivered by the lecturer. this activity requires high concentration and can be greatly disturbed by trivial matters such as the sound of surrounding conversation, signal interference, and so on. so it is not surprising if then the three aspects above become the most dominant factor in the occurrence of mental workload on students who are carrying out online learning activities.

| Table 3. Comparison of NASA TLX score elements |
|---|---|---|---|
| Category | Score | Average | Percentage |
| MD | 17032 | 210,2716 | 20% |
| PD | 4314 | 53,25926 | 5% |
| TD | 16661 | 205,6914 | 20% |
| OP | 13090 | 161,6049 | 16% |
| EF | 16014 | 197,7037 | 19% |
| FR | 16067 | 198,358 | 19% |

4. Conclusion
The online learning process carried out by industrial engineering students of the Sultan Ageng Tirtayasa University has a psychological impact in the form of mental workload on these students. The results showed that 63.21% of students experienced mental workloads with moderate classification, 22.97% of students had workloads with heavy classifications while the rest experienced light workloads (13.51%). The most dominant indicators are Mental Demand, Temporal Demand, and
Frustration Level. The three indicators are more influential on the mental activity experienced by students during online learning compared to physical activity. This is caused by constraints related to learning facilities and infrastructure, physical complaints, and psychological complaints.

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