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Experimental Ergonomic Approach in Analysis of Student Mental Workload in Using Learning Management System

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Abstract. *Student interactions with the devices and software used can result in excessive mental workload, which of course also has an impact on decreasing productivity and work functions and indirectly harms student health, as well as student interactions in using the Learning Management System (LMS). Which is expected to continue to be utilized and developed to achieve greater convenience and profit, LMS is expected to continue to be developed and utilized optimally. This study is intended to analyze the mental workload felt by students in the learning process through LMS. An experimental ergonomics approach is used in this study by applying the modified NASA-TLX method. The results of the research experiment show that students feel a high mental workload when using the assignment module, quiz module, and forum module on the LMS, these modules produce a high mental workload due to cognitive difficulty, instruction complexity, and work habits.*

Keywords: *ergonomic, experimental approach, mental workload, NASA-TLX*

I. INTRODUCTION

Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) or commonly called the Coronavirus is a virus that interferes with the respiratory system, the respiratory system infection caused by this virus is called COVID-19, this virus can cause mild respiratory problems to death (Wang et al., 2020), this virus became a world pandemic. In Indonesia, the number of positive cases of COVID-19 continues to increase significantly, so policies to break the chain of transmission of the Coronavirus are implemented, including implementing online learning (Fantriadi et al., 2021). In the Joint Decree of the 4 Ministers on Guidelines for the Implementation of Learning During the 2021 COVID-19 Pandemic, the Governor of Central Java's Instructions on the Implementation of Restrictions on Community Activities in 2022, and the Decree of the Chancellor of the Institut Teknologi Telkom Purwokerto (ITTP) concerning the Determination of the Model for the Implementation of Teaching and Learning Activities in the Even Semester of 2021/2022 which regulates the process of implementing education during the Coronavirus outbreak which must be carried out online from home for universities including the ITTP domiciled in Central Java.

Online learning methods are carried out using technology such as smartphone devices, computers, or laptops that are connected to the internet network (Hoi et al., 2018). The implementation of online learning activities involves devices and a variety of software to assist their implementation (Didin et al., 2020), in this case, of course, there is an interaction between students and devices and various other devices used, in general, this interaction is referred to as Human-Computer Interaction, which is defined as human relationships and interactions with devices and interactive devices in them (Dalle et al., 2019). A human-computer interaction involves humans interacting with computer-based interactive products through an intermediary medium known as an interface. The interface is a bridge between

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the world of interactive products and the world of users (Hookway, 2014). The interface must be able to facilitate the user's work easily and clearly, so that the better the existing interface, the easier it will be for users to use the interface in doing their work (Mardhia & Bariyah, 2020).

From the human factor, when students interact with devices and other learning devices in the online learning process, of course, a cognitive process is needed to process the information that arises from these interactions (Febiyani et al., 2021; Kim, 2016), where the cognitive process in the online learning process certainly causes a separate workload for students, which leads to mental fatigue (Febiyani et al., 2021). Based on the description above, the urgency of a study about the mental workload felt by students when undergoing online learning is important to do to create a healthy and productive online learning ecosystem. One of the interactive products used in the online learning process is the Learning Management System (LMS), where LMS is a web-based application with an internet connection (Llantos & Estuar, 2018). Even though the COVID-19 pandemic, especially in Indonesia, is now starting to subside, the convenience and benefits that come from the online learning process with all forms of media, interactive products, methods, and other tools (Hermanto & Sidqon, 2020; Khusniyah & Hakim, 2019; Oktavian & Aldya, 2020; Sutini et al., 2020) are expected to continue to be utilized and developed to achieve greater convenience and benefits, including LMS which is widely used, LMS is expected to continue to be developed and utilized optimally. Studies on LMS are mostly technical with an emphasis on the results of evaluating the process of human interaction in using LMS (Dzandu & Tang, 2015).

This research will take a study on the interaction of using the LMS interface at the ITTP, where this research will conduct a test related to the possibility of mental worklaod experienced by students when interacting with the LMS of the ITTP through an experimental ergonomics approach. In student interactions with devices and software such as LMS which are used to support learning through existing interfaces, of course, there is an increase in workload (Afridi, 2019), this is in line with the concept of human-computer interaction involving the discipline of ergonomics (Dalle et al., 2019). Ergonomics can be defined as the study of the relationship between people and the work environment. The application of ergonomics is closely related to efforts to reduce the occurrence of work functions and also to improve occupational health and safety (Susanti et al., 2015). So it can be concluded that the workload of students in the online learning process must be reduced to achieve the highest learning effectiveness by using an ergonomic approach to maintain the health of student learning.

The workload is defined as a condition that indicates the operator's inability to complete work. So it is necessary to measure the workload as a form of effort to classify the performance characteristics of each job that can be adjusted to the capabilities or abilities of workers (Tarwaka & Bakri, 2004). There are external factors and internal factors that cause the emergence of workloads (Wiebe et al., 2010), external factors include things related to work such as work facilities, work stations, work tools, work attitudes, length of work time, rights, and authorities work, and more. While internal factors include somatic factors such as age, gender, condition, health, body size, and nutritional status. Workload has a relationship with fatigue, the higher the workload, the higher the risk of fatigue that will occur (Azwar & Candra, 2019).

From the mental aspect, fatigue can trigger stress which has an impact on individual health and the work environment (Astuty et al., 2013; Fitri, 2013). The excessive mental workload can reduce cognitive function and human performance, and as a result, this can reduce work productivity and affect worker's health when doing work (Kim, 2016). Psychological workload or mental workload shows the portion of workers in the process of absorbing the resources or capacity that is needed to meet system needs. However, in general, the workload can be expressed as an idea of mentality that reflects the mental stress resulting from carrying out a job in a certain operational environment and conditions, compared to the operator's capability or ability to

respond to the request (Tarwaka & Bakri, 2004). Likewise for students, in conducting online learning, student interactions with the devices and software used can result in excessive mental workload, which of course also has an impact on decreasing productivity and work functions and indirectly harms student health.

In measuring mental workload, there are objective or subjective methods that can be applied, but objective measurement of mental workload is rarely applied because it is expensive and has inaccurate results (Febiyani et al., 2021). Mental workload measurement generally uses subjective methods, because it is cheaper and has more representative results, the method that is often used is the NASA-TLX. This method is a research method that measures workload scores multidimensionally, of which 6 dimensions are assessed (Susanto & Azwar, 2020). In NASA-TLX the dimensions that are assessed are Mental Demand, Physical Demand, Temporal Demand, Own Performance, Frustration Level, and Effort (Mardhia & Bariyah, 2020). Several studies using NASA-TLX to measure mental workload apply this method with an overall subjective approach, where respondents will assess the 6 dimensions that exist completely subjectively, only based on how respondents feel when doing a job (Astuty et al., 2013; Azwar & Candra, 2019; Febiyani et al., 2021; Mardhia & Bariyah, 2020; Mehta & Agnew, 2011; Susanto & Azwar, 2020).

Of the several methods used to measure the mental workload of workers in doing their work, this research will use the NASA-TLX method, the NASA-TLX method is used because of the ease of measurement and good representation of results, but to add objectivity to the use of this method and provide a novelty, this study will modify the NASA-TLX method by conducting objective measurements experimentally on 2 existing dimensions using the developed measuring instrument, the two dimensions measured objectively are Mental Demand and Own Performance because the process and output obtained from the use of LMS by students Online lectures are closely related to these two dimensions, where the process of searching, selecting, and processing information which is a Mental Demand will affect work results which are Own Performance (Febiyani et al., 2021).

So that this study is intended to analyze the mental worload felt by students in the learning process through LMS at the ITTP through an experimental ergonomics approach using the modified NASA-TLX method. This research is also expected to be a form of intervention at the LMS of the ITTP so that it can be used appropriately to obtain optimal results. In the LMS used at the ITTP, the system template used is Moodle, where this system template is commonly used in LMS in the majority of universities in Indonesia, it is hoped that the results of this study can be applied massively in Indonesia.

II. RESEARCH METHOD

In general, this research was carried out in several stages which are described in the flowchart in Figure 1. After conducting a literature review on several previous studies and determining the direction and objectives of the research, an experimental measuring instrument was developed based on data on the frequency of use of the LMS general module in ITTP, where there are 10 general modules used in experimental measuring instruments to be developed, the selection These 10 general

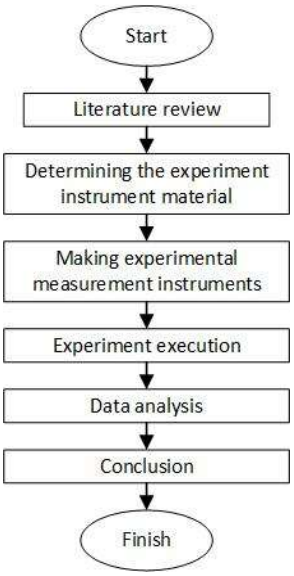

Figure 1. Research flowchart

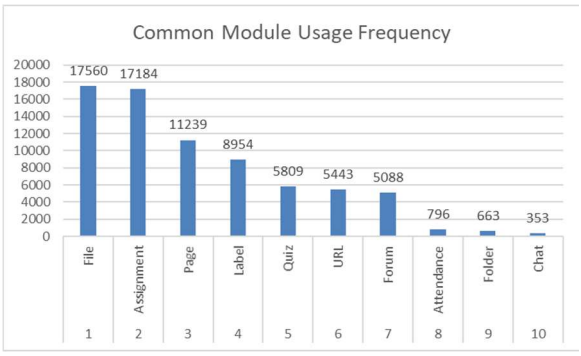

Figure 2. Common module usage frequency

	MD	PD	TD	OP	EF	FR
MD						
PD						
TD						
OP						
EF						
FR						

Figure 3. NASA-TLX Pairwise Option Matrix

modules are based on the highest frequency of use, the modules used are: File, Assignment, Page, Label, Quiz, URL, Forum, Attendance, Folder, and Chat, in addition to the highest frequency, the general module was chosen so that the results of this study can be generalized to contribute to the general use of LMS without being limited to a single concentration of education. The frequency of use of the ten modules is shown in Figure 2.

Experimental measuring tools were also developed based on the understanding and purpose of each module according to the Moodle system template. Where the meaning and purpose of each module selected (Tim IT Support & Pengembangan Pembelajaran, 2018) is explained as follows:

1. File module, allows lecturers to provide files as course resources, files may include supporting files.
2. Assignment module, allows lecturers to communicate assignments, collect work and provide grades and feedback.
3. Page module, allows lecturers to create web page sources using a text editor.
4. The Label module, allows text and multimedia to be inserted into course pages between links to other resources and activities. Labels are very versatile and can help improve the appearance of learning to use with care.
5. Quiz module, allows a lecturer to create a quiz consisting of questions of various types, including multiple-choice, matchmaking, short answers, and numeric.
6. URL module, allows lecturers to provide web links as course resources. Certain web page URLs can be copied and pasted.
7. Forum module, allows participants to conduct asynchronous discussions, namely discussions that take place over a long period.
8. Attendance module, allows a lecturer to take attendance during class and students to view their attendance records.
9. Folder module, allows lecturers to display several related files in one folder, reducing scrolling on course pages.
10. Chat module, allows participants to conduct synchronous real-time text-based discussions.

Of the 10 modules used in this study, then the making of instruction points is carried out to accommodate the objectives of each module on the measuring instrument developed, the instruction points are described in Table 1.

In general, this study will use the NASA-TLX method which has 6 measurement dimensions to calculate and analyze experimental data, where there will be a rating value of the 2 NASA-TLX dimensions which will be measured objectively through an experimental process and user response time observations, while the Ratings from the other 4 dimensions are still measured objectively based on how respondents feel when conducting experiments. The dimensions of Mental Demand (MD) and Own Performance (OP) will be measured objectively while the dimensions of Physical Demand (PD), Temporal Demand (TD), Effort (EF), and Frustration Level (FR) will be measured subjectively.

To facilitate the process of access and communication with respondents, experimental measuring instruments were made in Bahasa and used a video as an instructional tool, instructional videos were also used to generalize the standards

Table 1. Module's Instruction Point

No	Module	Instruction
1	File	Please select and download a PDF FILE with the name TEST 02. Choose a file according to the pre-defined class.
2	Assignment	Please do ASSIGNMENT with the names TEST 01 and TEST 02 respectively. Choose an assignment according to the pre-defined class. Do it according to the instructions in the questions in each assignment.
3	Page	Please select PAGE with the name TEST 03. Select the page according to the pre-defined class.
4	Label	Please click "Mark as Done" on the LABEL with the name TEST 02. Select the label according to the pre-defined class.
5	Quiz	Please do all the questions in QUIZ with the name TEST 03. Choose the quiz according to the the pre-defined class.
6	URL	Please access the URL with the name TEST 03. Choose the URL according to the pre-defined class.
7	Forum	Please select FORUM with the name TEST 02. Select the forum according to the pre-defined class. After that create a NEW DISCUSSION TOPIC with your name and a message containing YOUR STUDENT NUMBER. Finally, give a REPLY to the DISCUSSION TOPIC named TEST B Comment with YOUR FULL NAME.
8	Attendance	Please do ATTENDANCE with the name TEST 02. Choose attendance according to the pre-defined class, and do attendance in the GROUP according to your class.
9	Folder	Please select a FOLDER with the name TEST 01. Choose a folder according to the pre-defined class. After that, select EXCEL type FILE with the name TEST 02.
10	Chat	Please do a conversation on CHAT with the name TEST 04, and follow the instructions on the chat. Choose the chat according to the pre-defined class.

accepted by all respondents. And to be more representative, all experimental measuring tools consisting of 10 modules can be accessed through the LMS platform. Due to the willingness of respondents and limited experimental facilities, this experiment involved 47 students at the Institut Teknologi Telkom Purwokerto who used LMS since the beginning of the lecture, all respondents were divided into 4 large groups which would later be called classes.

During the experiment, all participants will be asked to work on each existing measuring instrument one by one, and followed by weighting for each measuring instrument that has been completed, the weighting is carried out in pairs on the 6 NASA-TLX dimensions shown in the matrix on Figure 3.

Furthermore, respondents were asked to give subjective ratings according to what they felt when working on experimental measuring instruments on the dimensions of Physical Demand (PD), Temporal Demand (TD), Effort (EF), and Frustration Level (FR) on a scale of 0-100 in multiples 5 with the explanation in Figure 4.

Meanwhile, the rating dimensions of Mental Demand (MD) and Own Performance (OP) are measured objectively through the results of screen recording when respondents work on each existing measuring instrument and by using User Response Time analysis which considers the duration of work response and buffers on the LMS system. In providing an assessment of the Mental Demand (MD) dimension, Student Task-Completion Work-Time from Periods of Silence becomes a time reference (Kemalasari & Zainil, 2021; Rowe, 1974), where when the respondent can do each instruction in under 5 seconds and is correct then will get a minimum rating, whereas if the time needed to do each instruction is more than 5 seconds and wrong, it will get a maximum rating.

Then to give an assessment on the Own Performance (OP) dimension, the respondent's work is measured based on the standard of success made by the experimenter (Hart &

Physical Demand (PD)																				
What level of physical needs do you need to work on this module?																				
0 LOW	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100 HIGH
Temporal Demand (TD)																				
What level of time pressure did you feel while working on this module?																				
0 LOW	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100 HIGH
Effort (EF)																				
What level of stress-related discomfort did you feel while working on this module?																				
0 LOW	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100 HIGH
Frustation Level (FR)																				
What is the total level of effort you put into working on this module?																				
0 LOW	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100 HIGH

Figure 4. Subjective Dimension Rating

Mental Demand (MD)	
How long does it take the respondent to respond to each experimental instruction?	
0-25	≤ 3 seconds and correct
30-50	≤ 3 seconds and wrong
55-75	> 3 seconds and correct
80-100	> 3 seconds and wrong
Own Performance (OP)	
How high is the success rate of respondents in carrying out each experimental instruction?	
0	Wrong
5-25	Partly Correct by Searching
30-50	Partly Correct
55-75	Completely Correct by Searching
80-100	Completely Correct

Figure 5. Objective Dimension Rating

Steveland, 1988) in each module, where when the respondent cannot complete all instructions correctly, he will get a minimum assessment, and On the other hand, when the respondent cannot complete all instructions correctly, he will get the maximum rating. The rating scale is assessed in multiples of 5 with detailed objective assessments on the dimensions of Mental Demand (MD) and Own Performance (OP) described in Figure 5.

After getting the weights and ratings for the six existing dimensions, the NASA-TLX calculations are carried out which include calculating the product value for each dimension on each experimental measuring instrument using equation (1) (Taslim & Afifah, 2021).

$$Product\ Value = Dimensional\ Weight \times Dimensional\ Rating \quad (1)$$

Furthermore, the product value from each dimension is converted into WWL by accumulating all existing product values using equation (2) (Bariyah & Siahaan, 2022).

$$WWL = \sum Product\ Value \quad (2)$$

And finally, to represent the level of mental workload, the NASA-TLX score is calculated using equation (3) (Taslim & Afifah, 2021) as follows:

$$Score = \frac{WWL}{15} \quad (3)$$

From the scores obtained, a representation of the level of mental workload in the low to very high category is carried out which is detailed in Table 2 (Handoyo & Maharani, 2021).

Based on the representation of the level of mental workload felt by the respondent when

Table 2. Category of Mental Workload

Score	Category of Mental Workload
0-9	Low
10-29	Moderate
30-49	Fairly High
50-79	High
80-100	Very High

Table 3. P-Value of NASA-TLX Normality Test

Module	Ryan Joiner Normality P-Value of NASA-TLX Score	Normality
File	0.076	Normal
Assignment	> 0.100	Normal
Page	0.089	Normal
Label	> 0.100	Normal
Quiz	> 0.100	Normal
URL	0.098	Normal
Forum	> 0.100	Normal
Attendance	> 0.100	Normal
Folder	> 0.100	Normal
Chat	> 0.100	Normal

working on each existing experimental measuring instrument, an analysis was carried out in terms of the overall mental workload and in terms of the dimensions that most influence the emergence of mental workload.

III. Results and Discussion

Based on experiments that have been carried out on 2-3 July 2022 on 47 respondents using measuring tools that have been developed along with predetermined calculation parameters, after obtaining weighting and dimension ratings both objectively (Mental Demand [MD] and Own Performance [OP]) or subjectively (Physical Demand [PD], Temporal Demand [TD], Effort [EF], and Frustration Level [FR]), then the weighting and rating are processed into product values, WWL, and NASA-TLX scores for all modules in existing measuring instruments.

To represent data on the level of mental workload felt by all respondents in each experimental measuring instrument module, the existing NASA-TLX scores from all respondents were tested for normality and averaged, from the normality test, all respondent data in each experimental measuring instrument module can be said normally distributed with p-value > 0.05. All data in each experimental measuring instrument module which are normally distributed are then averaged to be categorized into mental workload levels. P-value normality of the NASA-TLX score for each module and the average product value of each dimension, the average NASA-TLX score, and the category of mental workload levels in each module can be seen in Table 3 and Table 4.

Based on the normality test and descriptive statistical analysis that has been carried out, the level of mental workload felt by respondents in working on all the modules in the Learning Management System (LMS) can be seen in the graph in Figure 5.

Based on experiments and calculations that have been carried out, the highest level of mental

Table 4. Product Value and NASA-TLX Score Average Result

Module	Average Product Value						Average NASA-TLX Score	Mental Workload Category
	MD	PD	TD	OP	EF	FR		
File	91	53	146	183	165	64	46.730	Fairly High
Assignment	106	64	144	156	217	85	51.468	High
Page	81	66	117	246	138	45	46.206	Fairly High
Label	93	72	101	212	174	47	46.658	Fairly High
Quiz	117	69	158	146	237	77	53.635	High
URL	69	76	115	230	173	42	46.993	Fairly High
Forum	197	46	131	77	213	101	51.142	High
Attendance	75	83	101	230	177	42	47.206	Fairly High
Folder	106	77	123	167	183	50	47.085	Fairly High
Chat	78	87	93	232	187	30	47.118	Fairly High

workload felt by respondents when using LMS was when respondents used the Assignment, Quiz, and Forum modules with NASA-TLX scores of 51.468, 53.635, and 51.142, respondents felt the workload mentally high when using these three modules. Using root cause analysis conducted on several respondents, specifically using 5-whys analysis, respondents stated that the assignment module and quiz module have a high level of cognitive difficulty because these two modules require special understanding and complex instructions depending on the questions in each. assignments and quizzes are given, so this indicates the emergence of a high mental workload (Mohzana et al., 2021).

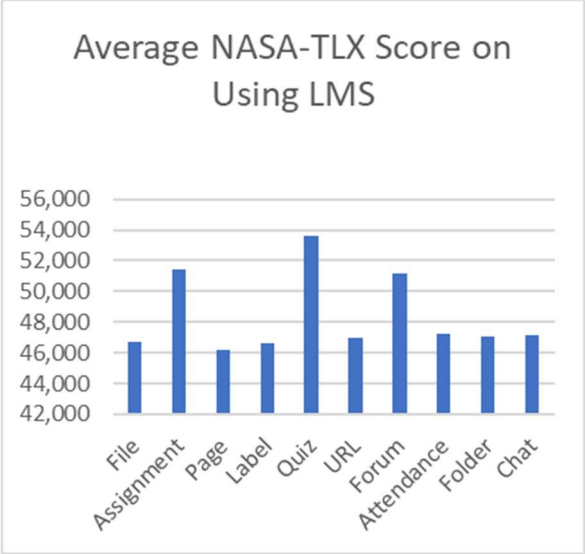

Figure 5. Average NASA-TLX Score on Using LMS Graph

While in the forum module, respondents stated that this module is rarely used by students, although it often appears on every existing LMS course, so that when respondents use this module, the level of cognitive needs that appears is quite high, because work habits can also cause mental workloads. on workers when doing their jobs (Saputra, 2020). Objective experiments in measuring mental workloads that were carried out showed that the respondent's work habits can also be measured and proven to result in a high level of mental workload, whereas when the respondent is not accustomed to using a module but is given a conditioned treatment and is required to use the module, the level of workload high mentality will emerge.

Of the three LMS modules that have a high level of mental workload, the dimension of mental load that has the biggest contribution in causing mental workloads is Effort (EF), with an average product value of 217 for the assignment module, 237 for the quiz module, and 213 for the forum module. In measuring mental workload, especially using the NASA-TLX method, the Effort (EF) dimension is an accumulation of physical effort and mental effort made by workers, so that the Effort (EF) dimension is consistently directly related to mental workload, the Effort (EF) dimension also represents the amount of physical and perceptual activity required (Hart & Steveland, 1988), where an interaction between humans and computers, in this case student interactions with the LMS platform, involves physical and perceptual activities.

IV. Conclusion

Based on research experiments that have been carried out on the mental workload felt by students in using the 10 general modules that are most widely used in the Learning Management System (LMS). The results of the research experiment show that students feel a high mental workload when using the assignment module, quiz module, and forum module on the LMS, these modules produce a high mental workload due to cognitive difficulty, instruction complexity, and work habits. The Effort (EF) dimension is the mental load dimension that has the biggest contribution in generating students' mental workload in using LMS, especially in the assignment module, quiz module, and forum module, because in human and computer interaction, the accumulation of physical and perceptual activities occurs intensely.

In using the LMS in the future, it is hoped that all stakeholders involved in developing and using the LMS can provide manual procedures to make it easier for students to use and encourage lecturers to simplify the instructions on each assignment and quiz. In addition, students are also expected to be able to use all existing

modules to bring up work habits to ease the mental workload felt by students. In the future, further research is expected to pay attention to the uniformity of the complexity of the instructions in the experiments carried out to increase the objectivity of the experiment, the addition of an objectively measured mental load dimension can also be added to reduce the subjectivity of the NASA-TLX method.

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