Improving Online Learning through Student Stress Evaluation

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Improving online learning through student stress evaluation

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ABSTRACT

The COVID-19 pandemic impacted almost all countries and caused disruptions in education. Governments, including Indonesia, closed schools and campuses to mitigate the spread of COVID-19, leading to a transition to online learning. This lasted for two years and continued with hybrid learning. The abrupt change increased stress, especially for already stressed students. This study assessed stress levels during online learning at the Industrial Engineering Study Programme of Maranatha Christian University, Bandung. Stress was measured subjectively using the Perceived Stress Scale (PSS) and objectively using Galvanic Skin Response (GSR) and pulse sensors on thirty-two students. The PSS results classified the stress perception of most students as 'normal' or 'moderate'. Meanwhile, the results of the GSR and pulse sensor measurements indicated that the students were stressed. Furthermore, a comparison of stress levels between synchronous and asynchronous learning and between mathematics and theory courses was conducted. According to the findings, there was a difference in the average heart rate values between synchronous and asynchronous learning. There was also a difference between mathematics and theory courses. With this research, it is necessary to pay attention to learning methods, materials, etc. need to be designed to reduce student stress and improve student performance.

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1. INTRODUCTION

The COVID-19 pandemic has changed many people's lives. COVID-19 not only affects health, but also affects social, economic, and educational conditions in the world, including in Indonesia. This happens because of the policies taken by most countries, namely isolation or quarantine, social distancing, and physical distancing as a form of effort to reduce crowds of people and the spread of the coronavirus [1]. Education and physical activities in schools and on campuses are forbidden and are being substituted by Internet activities. In fact, using online learning can increase students' digital skills in step with the evolution of contemporary educational trends [2]. However, there is a concern that this change affects the effectiveness of learning. Even though it is supported by online learning technology, gaps still can cause less effective learning [3].

In Indonesia, most students complain that the online learning process is not optimal because it is less conducive to the learning environment at home, resulting in less concentration and understanding, and because this system results in less socialization with classmates. Coupled with the use of electronic gadgets for extended periods every day, leading to exhaustion, health issues, and stress. Stress is a physiological

response in which individuals usually act against or avoid the source of the stress. Stress is damaging to the human body if it is permitted to persist for an extended period [4].

Stress can be considered one of the factors that increase the risk of diseases with serious consequences such as physical or mental illness. Therefore, stress must be controlled and managed by monitoring its development [5]. So, this study analyzes the stress that occurs in Industrial Engineering students, at Maranatha Christian University in Bandung, Indonesia due to online learning.

Online learning is carried out synchronously and asynchronously. Synchronous learning is a direct interaction between educators and students that occurs in real-time so that it allows two-way interaction at the same time, while in asynchronous learning, educators provide teaching materials in a learning management system that can be accessed and studied by students at different times and places [6]. Both synchronous and asynchronous learning is carried out online using electronic devices, such as computers, laptops, tablets, or cell phones that have the potential to cause stress.

In this study, stress will be measured subjectively and objectively. Subjective measurement is done with the Perceived Stress Scale (PSS). The PSS is a widely used instrument to measure perceived stress [7]. This method is designed to measure the extent to which situations in a person's life are assessed as stressful [8]. The PSS measures perceived stress through a questionnaire that includes several questions about feelings and thoughts over 1 month experienced by respondents. Objective measurements were made with Galvanic Skin Response (GSR) and heart rate. GSR is a continuous measurement of skin conductance that depends on perspiration in the skin and has been used as an objective measure of stress levels [9-12]. The higher the level of stress experienced by a person, will cause a reaction on the skin of a person's hand becomes cold, so the skin conductivity will increase. Along with the increase in skin conductivity, the resistance of the finger skin will also increase. This is because the nerves can deliver impulses using electrical signals [13]. GSR measurements are carried out by attaching the sensor to the respondent's palm so that it does not interfere with the activities of the respondent during data collection.

Until now, there have been many studies on stress using questionnaires given to students [14-17]. Some studies have also used PSS such as [18-21]. Research measuring stress levels using GSR was also found such as Hernandez et al. [9], Labbe et al. [10], Laeremans et al. [11], and Yan er al. [20]. Meanwhile, research examining heart rate variability was conducted by Chauhan et al. [22], Paolo et al. [23], Szakonyi et al. [24], and Zhang [25]. Research that measured GSR and checked heart rate at the same time was found including by Cantara and Ceniza [26] and Nurdina et al. [27] context of education. Many have measured stress levels, but none have done so subjectively and objectively at the same time, particularly when it comes to online learning in Indonesia.

This study will explore the differences in stress produced by two aspects, namely learning techniques (synchronous and asynchronous) and course kinds (mathematical and theoretical), in addition to assessing the amount of stress during online learning. This allows for the creation of a less stressful learning environment, hence reducing the impacts of stress on pupils and improving student achievement.

2. MATERIALS AND METHODS

PSS, GSR, and heart rate were used to assess student stress during online learning. The study goes on to compare the stress that happens in synchronous and asynchronous learning approaches, as well as in mathematical and theoretical courses.

In this study, stress measurement will be carried out on 32 students as observation respondents, consisting of students in semesters 2, 4, 6, 8, and 10. This selection is made to measure student stress in each semester with their respective study loads. This number is not too large, because when the research was conducted, it was still during the pandemic and students who were willing to be asked to carry out online learning on campus for measurement were very limited. Also, the number of students in each semester is different, because the number of students who are still taking courses is different. However, upper semester students were still taken in addition to seeing differences in stress, as well as to balance the number of students taking theoretical and mathematical courses.

The research participants were Maranatha Christian University Industrial Engineering students who were enrolled in the even semester 2021-2022. Data was collected between April 20, 2022, and June 13, 2022. The number of respondents in this study was 32 people, ranging from semester 2 to semester 10, based on students' willingness to participate and the compatibility of the chosen course schedule. Data was collected

for two factors: course type (Mathematical vs Theoretical) and online learning mode (synchronous vs asynchronous). Cost Analysis, Engineering Economics, Production Design and Control, Basic Mathematics, Physics, Industrial Statistics, Operational Research, and Statistical Data Analysis are the mathematical courses observed. The theoretical courses are Engineering Materials, Leadership and Teamwork, System Modeling, Industrial Psychology, Management Information Systems, Christian Religious Education, Work Physiology and Biomechanics, Product Design, Entrepreneurship, Quality Audit, Artificial Intelligence, and Work Design Analysis and Ergonomics 1. The synchronous learning method observed is when lecturers hold live meetings via Zoom or other online platforms. The duration of synchronous lectures attended by respondents ranged from 30 minutes to 1 hour.

Respondents were invited to fill out a self-profile data questionnaire via a Google form at the start of data collection. Respondents in this survey must be current students in the Industrial Engineering Survey Program between 2016 and 2020. The study team selected the observation period, which was tailored to the respondent's class schedule, to take measurements when the respondent was attending synchronous and asynchronous lectures for mathematical and theoretical courses.

Two devices were paired, namely GSR and Fingertip Pulse Oximeter Jumper JPD-500G (LED). The data displayed by the GSR device is in the form of numbers and graphs of the results of measuring sweat gland activity at the static (tonic) skin conductance level in units of microSiemens (μS) and at the dynamic (phasic) skin conductance level in units of Skin Conductance Response per minute (SCR/min). The bigger the number of sweat glands, the higher the conductance value on the device which is an indicator of measuring stress levels in respondents. The GSR recorded any variations in sweat gland activity that occurred in the tonic skin conductance solely in microSiemens (S) during the lecture. The recorded value is the value every second. As a result, the data used is each respondent's average tonic conductance value for each course. Fingertip Pulse Oximeter Jumper JPD-500G (LED) is attached to the student's finger to measure the respondent's heart rate during synchronous and asynchronous online learning. The measurement of heart rate can be thought of as the physical tiredness that a person feels while performing their tasks.

After the device was installed, the respondents were allowed to follow the online lecture. Heart rate is the number of heartbeats per unit of time, which is usually expressed in minutes/beats per minute (bpm). Factors that affect heart rate include physical activity, ambient temperature, emotional level, age, or medications being consumed. Figure 1 presents a detailed overview of the research process, starting from data collection, including heart rate and GSR measurements, to statistical analysis and the formulation of suggestions based on the findings. Figure 2 complements this by showing respondents equipped with GSR and Fingertip Pulse Oximeter devices, which were used to monitor physiological responses during the online lecture sessions, thereby providing valuable insights into the participants' emotional and physical states throughout the learning experience..

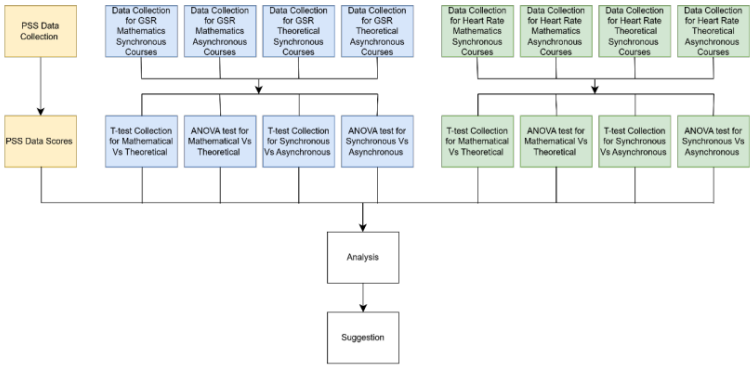

Figure 1. Research flow

Figure 2. Respondents with GSR device and fingertip pulse oximeter installed

After the online lectures were completed, respondents were asked to complete the PSS questionnaire which included 10 questions about the level of feelings and thoughts during the ongoing semester for synchronous and asynchronous learning methods for mathematical and theoretical courses. Scoring on the PSS questionnaire was based on responses, where 0 = Never, 1 = Almost Never (1-2 Times), 2 = Sometimes (3-4 Times), 3 = Almost Often (5-6 Times), 4 = Very Often (More than 6 Times). The scores of the 10 questions were then summed up. The results of measurements with the PSS, validity, and reliability tests are carried out, and if met, then proceed to determine the classification of stress levels. The stress level classification based on the PSS score is in the range of 0-40. The higher the score indicates the higher the stress level. If the PSS score is in the range of 0-13, it is considered that the respondent is experiencing low stress, the range of 14-26 is considered that the respondent is experiencing moderate stress, and the range of 27-40 is considered that the respondent is experiencing high stress. The questions of the PSS questionnaire are as follows:

1. During the past month, how often have you been angry about something unexpected?
2. During the past month, how often have you felt inadequate in control of the important things in your life?
3. During the past month, how often have you felt restless and depressed?
4. During the last month, how often did you feel confident about your ability to solve personal problems?
5. During the past month, how often have you felt that everything was happening according to your expectations?
6. During the past month, how often have you felt inadequate in finishing things that need to be done?
7. Over the past month, how often have you been able to control your taste irritability in your life?
8. How often have you felt more capable during the past month solving problems when compared to others?
9. During the past month, how often have you been angry because of a problem that you can't control?
10. During the past month, how often did you have trouble accumulating so that you are unable to cope with it?

During online learning, GSR detects any changes in sweat gland activity in tonic skin conductance in microSiemens. The findings of conductance and heart rate data collection will be examined for normality, independence, and homogeneity as a requirement of analysis of variance (ANOVA) testing first. If the conductance value and heart rate data are normal, the independent sample T-test difference test and analysis of variance are performed. Furthermore, it was determined whether differences in GSR data and heart rate data for mathematical and theoretical courses influenced the respondents analyzed. uses the T-test to determine the influence of each independent variable on the dependent variable [28]. When comparing mean differences between matched pairs, the sample t-test is often employed for statistical analysis of experimental data[29]. The analysis of variance test is used to determine whether the influence of independent factors on the dependent variable at the same time is significant [30]. In this study, due to limited flexibility during the COVID-19 pandemic and the number of credits taken by respondents, each respondent did not collect data for the four situations (Mathematics-Synchronous, Mathematics-Asynchronous, Theoretical-Synchronous, and Theoretical-Asynchronous), so the analysis of variance data processing in this study used a between-subject design model.

Stress can be categorized into four levels when measured with GSR and heart rate. Stressed, a state in which a person experiences dread or excessive tension, causing discomfort at the time; anxious (Tense), a condition in which there is a feeling of fear or considerable tension but not as great as in the stressed category; calm, a condition in which there is a minor feeling of fear or tension so that the person concerned does not experience distressing feelings; and relaxed, which is a state in which the person feels comfortable and tranquil, causing them to be pleased. Table 1 shows the limit of stress levels in adult conditions based on GSR and heart rate data.

Table 1. Limits of stress levels in adult conditions [31]

Condition	Parameter			
	GSR	HR(bpm)	BP(mmHg)	H&T
Relaxed	<2	60-70	100/70 – 110/75	36-37
Calm	2-4	70-90	110/75 – 120/85	35-36
Tense	4-6	90-100	120/9 – 130/110	33-35
Stressed	>6	>100	BPS > 130 BPD > 110	>33

GSR : Galvanic Skin Response ; HR : Heart Rate
BP : Blood Presure ; H&T : Heart and Temperature

In addition to these calculations, interviews were conducted with 10 students who had been involved in online learning to dig deeper into student conditions, obstacles, and advantages felt during online learning.

3. RESULTS

The results of PSS measurement show that most students experience perceived stress in the normal or "moderate" category (22 people or 69 %) as can be seen in Figure 3. Students experiencing perceived stress in the severe or "high" category show the least amount, followed by perceived stress in the mild or "low" category.

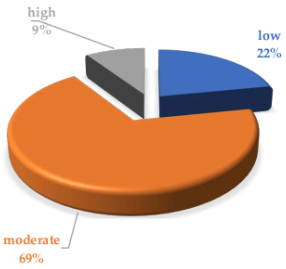

Figure 3. Percentage of respondent PSS scores

On average, students experience perceived stress in the normal or "moderate" category in semesters 2, 4, 6, and 10; while students in semester 8 experience perceived stress in the low category and there is 1 student in semester 10 who experiences perceived stress in the high category, as can be seen in Table 2. So, it can be concluded that overall students have experienced normal or "moderate" perceived stress in the last 1 month.

College activities in semesters 2, 4, and 6 still belong to many for the credits taken (around 19- 22 credits) so the college schedule experienced by students is quite tight. The most dominant factor causing students this semester of stress is too many college tasks and practicum tasks, so students become often less sleepy and easily tired.

Students in semesters 2, 4, and 6 still have a heavy credit load, averaging 19-22 credits per semester. With this much work comes a hectic schedule, assignments, and practicum. This increases the tension faced by students in semesters 8 and 10, who are nearing the end of their courses.

Table 2. Recapitulation of the number of PSS scores

Semester	Category		
	Low	Moderate	High
2	1	9	-
4	1	8	2
6	2	3	-
8	2	1	1
10	1	1	-

A different test was performed for the manner and kind of course based on the GSR and heart rate data acquired. Using an independent T-test and analysis of variance (ANOVA). The T-test is preceded by a normal distribution test, whereas ANOVA requires "ensuring that the data are independent, the dependent variable is normally distributed, and the variance of all treatment groups is the same (homogeneity) [32]. The SPSS Statistics program version 21 was used to administer the test in this study.

Independence testing for Mathematics-Synchronous GSR data, Mathematics-Asynchronous GSR data, Theoretical-Synchronous GSR data, and Theoretical-Asynchronous GSR data was conducted with Durbin-Watson. The results showed a Durbin-Watson value of 2.324 for GSR data and 1.705 for heart rate, so it was concluded that the data came from experiments conducted randomly.

Normality testing was conducted with Shapiro Wilk. Data is considered normally distributed if the significance value is > 0.05. The results of normality testing showed a significance value greater than 0.05, so it was concluded that the data were normally distributed.

For mathematical (synchronous and asynchronous) and theoretical (synchronous and asynchronous) GSR data, homogeneity testing was performed using the Levene Test. The test findings show that the significant value for GSR data is 0.188 based on the mean value and 0.849 based on heart rate data. The result is more than 0.05, implying that the data is homogeneous.

The data can be continued with the independent sample T-test and analysis of variance testing based on the results of the assumption tests in Table 3.

Table 3. Recapitulation of assumption tests of GSR data and heart rate data

	The Skin Conductance Data				Heart Rate Data			
Data Independence Testing	**Sig value. Durbin Watson**	**Sig**	**Decision**	**Conclusion**	**Sig value. Durbin Watson**	**Sig**	**Decision**	**Conclusion**
Mathematical Conductance Values (Synchronous & Asynchronous) and Theoretical (Synchronous & Asynchronous)	2,324	0.05	1 <2,324 <3 (Do not reject H0)	Data is independent	1,705	0.05	1 <1,705 <3 (Do not reject H0)	Data is independent
Data Normality Testing	**Sig value. Shapiro-Wilk**	**Sig**	**Decision**	**Conclusion**	**Sig value. Shapiro-Wilk**	**Sig value**	**Decision**	**Conclusion**
Mathematical-Synchronous conductance value	0.246	0.05	0.187> 0.05 (Do not reject H0)	Data is normally distributed	0.325	0.05	0.325> 0.05 (Do not reject H0)	Data is normally distributed
Mathematical-Asynchronous Conductance Value	0.086	0.05	0.086> 0.05 (Do not reject H0)	Data is normally distributed	0.239	0.05	0.239> 0.05 (Do not reject H0)	Data is normally distributed

Theoretical-Synchronous conductance value	0.053	0.05	0.053> 0.05 (Do not reject H0)	Data is normally distributed	0.176	0.05	0.176> 0.05 (Do not reject H0)	Data is normally distributed
Theoretical-Asynchronous Conductance Value	0.344	0.05	0.344> 0.05 (Do not reject H0)	Data is normally distributed	0.137	0.05	0.137> 0.05 (Do not reject H0)	Data is normally distributed
Data Homogeneity Testing	**Sig value. Lavene test**	**Sig**	**Decision**	**Conclusion**	**Sig value. Lavene test**	**Sig**	**Decision**	**Conclusion**
Mathematical Conductance Values (Synchronous & Asynchronous) and Theoretical (Synchronous & Asynchronous)	0.188	0.05	0.188> 0.05 (Do not reject H0)	Homogeneous distribution data	0.849	0.05	0.849> 0.05 (Do not reject H0)	Homogeneous distribution data

From the sample T-Test results, the GSR data obtained has a sig. value greater than 0.05 which means Accept H0 as can be seen in Table 4. This means that based on objective measurements using Galvanic Skin Response (GSR) there is no difference in stress levels between the factors of course type and learning method.

Table 4. Recapitulation of GSR data independent sample T-test results

Indicator		P-value	Sig	Decision	Conclusion
Stress levels in mathematical and theoretical courses	The results of the synchronous method	0.799	0.05	0.799> 0.05 (Do not reject H0)	There is no difference between the stress levels in mathematical and theoretical courses when learning with the synchronous method.
	The results of the Asynchronous method	0.957	0.05	0.957> 0.05 (Do not reject H0)	There is no difference between the stress levels in mathematical and theoretical courses when learning with the Asynchronous method.
Stress levels in Synchronous and Asynchronous Learning Methods	The results of the mathematical courses	0.372	0.05	0.372> 0.05 (Do not reject H0)	There is no difference between the stress levels during college with the synchronous and asynchronous methods in mathematical courses.
	The results of the theoretical course	0.353	0.05	0.353> 0.05 (Do not reject H0)	There is no difference between the stress levels during college with the synchronous and asynchronous methods in theoretical courses.

In contrast to the results of the T-Test test and the GSR data test, the results of the T-Test for heart rate data are as in Table 5 show that there is 1 indicator that rejects H_0 (Accept H_1), namely, there is a difference in the average value between heart rate during lectures with synchronous and asynchronous methods in mathematics courses with a p-value of 0.004.

Furthermore, ANOVA was conducted to analyze whether there is an influence between the factors of course type, learning method, and the interaction of the two methods on the average student stress level (GSR and heart rate data) during online learning. The following is the hypothesis structure for testing GSR data:

H_1 : There is an influence of the type of course factor on student stress levels.

H_2 : There is an influence of learning methods factor on student stress levels.

H_3 : There is an influence on the type of course factor and the type of learning method factor on student stress levels.

Table 5. Recapitulation of heart rate data independent sample T-test results

Indicator		P-value	Sig	Decision	Result
Heart rate in mathematical and theoretical courses	The results of the synchronous method	0.908	0.05	0.908> 0.05 (Do not reject H0)	There is no difference between the heart rate in mathematical and theoretical courses when learning with the synchronous method.
	The results of the Asynchronous method	0.304	0.05	0.304> 0.05 (Do not reject H0)	There is no difference between the heart rate in mathematical and theoretical courses when learning with the Asynchronous method.
Heart rate in synchronous learning methods and asynchronous	**The results of the mathematical courses**	**0.004**	**0.05**	**0.004 <0.05 (Reject H0)**	**There is a difference between the heart rate during college with the synchronous and asynchronous methods in mathematical courses.**
	The results of the theoretical course	0.05	0.05	0.05 ≥ 0.05 (Do not reject H0)	There is no difference between the heart rate during college with the synchronous and asynchronous methods in theoretical courses.

Based on Table 6, it is obtained that the p-value. greater than 0.05, namely do not reject H_0 which means there is no influence on the type of course factor on student stress levels; there is no influence of learning methods factor on student stress levels and there is no influence on the type of course factor and the type of learning method factor on student stress levels.

Based on ANOVA testing for heart rate data in Table 7, it is known that there is 1 indicator that there is an influence between the applied learning method factors (synchronous and asynchronous) on the average student heart rate value with a p-value <0.05. This is in line with the results of the average level of stress experienced by students which can be seen in Table 5. The tension experienced during lectures causes differences in student heart rates during these learning methods.

Table 6. Test Results of analysis of variance for GSR data

Factor	P-value	Sig	Decision	Conclusion
Courses Factor (Mathematical and Theoretical)	0.820	0.05	0.820> 0.05 (Do not reject H0)	There is no influence on the type of course factor on student stress levels.
Learning Methods Factor (Synchronous and Asynchronous)	0.202	0.05	0.202> 0.05 (Do not reject H0)	There is no influence of the learning methods factor on student stress levels.
Interaction of Learning courses and learning methods	0.876	0.05	0.876> 0.05 (Do not reject H0)	There is no interaction influence on the type of course factor and the type of learning method factor on student stress levels.

Table 7. Test results of analysis of variance for heart rate data

Factor	P-value	Sig	Decision	Conclusion
Courses Factor (Mathematical and Theoretical)	0.441	0.05	0.441> 0.05 (Do not reject H0)	There is no influence on the type of course factor on student heart rate.
Learning Methods Factor (Synchronous and Asynchronous)	**0.001**	**0.05**	**0.001 <0.05 (Reject H0)**	**There is an influence between the learning methods factor on student heart rate.**
Interaction Learning courses factor and learning methods factor	0.550	0.05	0.550> 0.05 (Do not reject H0)	There is no influence on the type of course factor and the type of learning method factor on student heart rate.

4. DISCUSSION

If we look in more detail at Table 8 and Figure 4, we can see a comparison of stress level conditions based on the categories in Table 1 based on GSR and heart rate measurements. In general, the average student experiences stress levels in the "Stressed" category of 50% or above, namely in the Mathematics-Synchronous and Theoretical-Synchronous learning techniques.

Table 8. Classification of student conditions based on GSR data and heart rate data

Condition	Mathematics				Theoretical			
	Synchonous		Asynchronous		Synchonous		Asynchronous	
	Total	%	Total	%	Total	%	Total	%
Relaxed	0	0,00%	0	0,00%	0	0,00%	0	0,00%
Calm	3	18,75%	6	37,50%	4	25,00%	5	31,25%
Tense	4	25,00%	4	25,00%	4	25,00%	6	37,50%
Stressed	9	56,25%	6	37,50%	8	50,00%	5	31,25%
Total	**16**	**100,00%**	**16**	**100,00%**	**16**	**100,00%**	**16**	**100,00%**

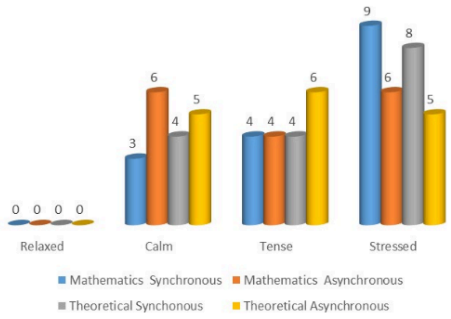

Figure 4. Classification of respondent conditions

Subjective and objective assessments yield different results; subjectively, pupils feel felt stress in the “normal” or "moderate" range, whereas objective measurements reveal stress. This happened because when measurements were taken from April to June 2022, the COVID-19 pandemic in Indonesia had begun to decline, and learning began to be carried out in a face-to-face manner, although still with strict health protocols and a

very limited number of meetings. This condition affects the psychology of students. Students began to calm down and have hope for good and normal conditions like before the COVID-19 pandemic occurred. Students have also begun to be able to interact directly with friends, especially second-semester students who have been able to get acquainted directly with their classmates. Furthermore, when measures were collected, online learning had been carried out for four semesters for students other than second-semester students, so students had begun to become accustomed to the environment of online learning, such as the usage of devices and learning platforms. As a result, they perceived typical stress levels. However, actual stress remains, particularly for specific learning methods and courses. When participating in online learning, students may be less aware of the stress they are putting on themselves.

From the objective measurement, 1 indicator was found to be influential according to the Independent T-Test and 1 indicator was influential according to ANOVA Test. Although statistically there is no difference, after analyzing by number, students fall into the stressed category in the types of mathematical synchronous and theoretical synchronous courses and learning, as can be seen in Table 8 with the number of 50% and above.

A synchronous learning environment is one in which teachers and students meet online on some online platform to teach and communicate a lesson[33]. The highest stress level occurs in mathematical synchronous. In general, in mathematical synchronous lectures, students are more required to be active in class. Online learning is where lecturers do not directly meet face-to-face with students, making it difficult for lecturers to have full control over learning. Signal difficulties and student quotas often cause more students to choose off-cam during learning, making it difficult for lecturers to see their reactions. When lecturers ask questions or problems, students are often reluctant to answer, instead, they often carry out lectures while doing other work. Therefore, lecturers need to often ask questions or ask for opinions by directly calling students' names. In this condition, students become afraid of being called and then cannot answer. This is what causes students to become stressed.

Students' doubts and anxieties produce stress since they believe they do not fully understand the materials offered. Students became more hesitant to question lecturers if there was any information, they did not grasp during the online learning period. Furthermore, during the COVID-19 epidemic, Maranatha Christian University introduced a flip learning system. The transmission of material by lecturers is inverted in this arrangement. Previously, instructors would present information directly face-to-face (synchronous), and students would subsequently study at home, either through assignments or homework (asynchronous). During the course, students are required to first asynchronously study the lecturer's content on the learning platform, and then meet with the professor online (synchronously) to discuss the topic. As a result, it is emphasized here that students must first learn autonomously. Stress can also emerge when students do not prepare themselves or study the lecturer's prepared content.

According to the findings of the interviews, students experienced stress during online learning because they were not used to it, as well as less supportive electronic devices, an unsupportive learning environment, a lack of interaction with friends, more difficulty understanding learning materials, and difficulty communicating with lecturers. Most students stated that the time needed to adapt to the learning system during the pandemic was 3 months - 6 months. So, at the time of this research when the pandemic has been running for almost 2 years, students have begun to get used to and feel comfortable with the online learning situation.

Some of the challenges that cause stress that are frequently encountered by students during synchronous learning are as follows:

1. Some students feel that the features of the platform application are not as effective as the media used offline in class. For example, the use of a whiteboard in the Zoom application is not as wide as the whiteboard in the classroom.
2. Some students continue to experience low internet signal quality.
3. Some students dislike online mathematics courses because they are sometimes hampered by internet connection signal issues.
4. Some students are demotivated to learn because they lack interaction and direct communication with other students.

In addition to the obstacles faced above, students also feel that there are advantages and things they like during the learning period during the pandemic, namely:

1. More flexible in time

2. Save more time, transportation costs, boarding fees, and living costs
3. Capable of learning and multitasking.

Although online learning has various weaknesses and obstacles, it is no less effective than face-to-face learning [34], [35], [36], [37], so it has the potential to be used in the future. Various things can be done to alleviate stress during synchronous learning, including:

1. Make it clear to students that synchronous learning cannot take place while they are doing other activities.
2. If possible, ask pupils to be on camera during the learning process. If this is not possible, ask students to be on camera for a set period to assess their health.
3. Most students still like direct interaction with lecturers which is felt face-to-face (onsite). Lecturers give assignments that force students to read the learning materials in advance so that when synchronous learning is implemented, students are ready and not afraid when the lecturer calls. Stress occurs in mathematical and theoretical synchronous courses and learning types. The highest stress level occurs in mathematical synchronous. Stress can be triggered by students' doubts and fears because they feel they do not fully understand the material provided. The tension experienced causes an increase in heart rate. Therefore, based on students' stress levels, online learning methods should be applied to be asynchronous. Based on experience in the field, it is known that not all students are able to understand the learning material with just one explanation. For this reason, lecturers should make short videos as asynchronous learning, so that explanations of learning materials can continue to be repeated by students until they really understand. The duration of the video also needs to be considered and can be a suggestion for further research by considering the concentration level and stress level of students. The asynchronous learning method also has some disadvantages, namely there can be a possibility that some students do not access the learning video, so classroom discussions become ineffective and inefficient. Based on this, it is suggested that the e-learning system used is added with features such as a reflection sheet that must be filled in and a notification that reminds students to watch the video before the class takes place. After watching, students are required to fill out a reflection sheet on each video that has been determined at each meeting. The results of this reflection sheet can be a guideline for lecturers to carry out further discussions on synchronous method lectures. The system will provide information to lecturers in the form of notifications of the names of students who have not accessed learning videos within a specified time frame so that lecturers can remind students to immediately access videos. If there are students who have never accessed the learning video at all, then the lecturer also gets the information, and the information can be forwarded to the student's guardian lecturer or parents via e-mail. If students have watched the videos well, it is hoped that communication between students and lecturers can run well, so that when asked by lecturers, students will not experience stress and tension anymore.
4. Lecturers make flip learning materials more appealing so that students are more interested and driven to learn the planned information ahead of time.

5. CONCLUSION

According to the findings of a study using subjective measurements, studying during the previous month causes perceived stress in the "normal" or "moderate" category for Industrial Engineering Study Program students in the even semester 2021-2022. Meanwhile, objective measurements show that students in the Mathematical-Synchronous and Theoretical-Synchronous learning techniques feel stress during their learning.

This study features flaws that can be exploited for future research, such as the fact that when this observation is carried out, respondents are occasionally bothered by the presence of researchers in the room. Furthermore, the use of the oximeter on the respondent's finger was unpleasant and interfered with the respondent's comfort while completing tasks on their laptop. Furthermore, the number of interviews done was still limited, with only 10 students chosen by chance.

To avoid interruption, research can be conducted directly in class or at the respondent's home to limit the vulnerabilities that emerge. Further research can be conducted by asking respondents to collect data directly (without the researcher present), and the usage of an oximeter can also be eliminated by utilizing an armband heart rate to reduce pain and discomfort. Furthermore, the number of students questioned should be doubled and drawn at random from different batches. Similar research can be conducted by employing alternative approaches and comparing the outcomes. Additional research direction can be provided by comparing stress levels during onsite learning versus stress levels during online learning. Further research can also be

conducted in other study programs and other universities both in Indonesia and outside Indonesia to increase the generalization of research results.

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