

Evaluation of Mental Fatigue of Students: A Comparison between Traditional and Online Learning in College Students

**Virlix Claire A. Estandian, Marc Christian C. Reyes, Robin D. Torres,
Ma. Janice J. Gumasing**

School of Industrial Engineering and Engineering Management
Mapua University

658 Muralla St. Intramuros, Manila, Philippines

vcaestandian@mymail.mapua.edu.ph, rdtorres@mymail.mapua.edu.ph,
mcreyes@mymail.mapua.edu.ph, mjjgumasing@mapua.edu.ph

Abstract

This study evaluated college students' mental fatigue between traditional face-to-face classes and online learning. Due to the coronavirus that started in the Philippines last March 2020, the students faced a fast transition to online learning. The teachers and students had a significant adjustment to that setup which affected the student's mental health, particularly mental fatigue. The researchers would like to assess and compare the mental fatigue of students between traditional and online learning; the researchers conducted a digital survey on the students with 100 respondents where 51% are females, and 49% are males. The Mental fatigue questionnaire was used, and it was reported that 86% of students experience mental fatigue online and 74% in traditional. The ANOVA results for the comparison of both modalities showed that in an online setup, students are more prone to mental fatigue, with a mean of 18.825 and 16.010 for a traditional setup. This study found that the only significant factor is the duration of study in an online class, and no factor was found to be significant in a traditional setup.

Keywords

mental fatigue, pandemic, online learning, traditional learning, college students

1. Introduction

According to studies, mental fatigue is a feeling people can have after or during periods of intense cognitive effort. These emotions are relatively prevalent in modern life. They usually include tiredness or even exhaustion, aversion to continuing the current activity, and a reduction in dedication to the task (Holding, 1983; Hockey, 1997; Meijman, 2000). Nowadays, students have their own experiences and judgments on the differences between both learning approaches. Some experiences cause mental fatigue and other health-related problems that affect the students' performances in school via Traditional or Online Learning. In a study by Mustika, et al. (2021), 274 medical students from the undergraduate level completed the survey in Malaysia. Students had moderate to strong favorable feelings regarding online learning, as well as high positive emotions and moderate negative emotions.

The researchers want to deal with the different perspectives of mental fatigue through Students between traditional and online learning modalities. The problem is incorporated through the psychological and mental ideologies wherein the effects could be varied. A study by de Oliveira Kubrusly Sobral et al. (2022) showed that 56% of students using the hybrid model experienced zoom fatigue, and 41% of students using the PBL method experienced zoom fatigue. The hybrid methodology differed from the PBL student by having a higher frequency of wanting and needing to be alone after a videoconference. On the contrary, a feasibility study was conducted by Podrigalo et al. (2016), which concluded that there was a gradual improvisation of mental fatigue, which was unsatisfactory by subjective feelings. Nevertheless, some students have experienced getting lower marks and not passing a single examination through some combination of pressure, time, and health, depending on their respective experiences through both modalities. The mental fatigue of students in the hybrid setup where both traditional and online are implemented showed higher mental fatigue than in the fully online setup (de Oliveira Kubrusly Sobral et al., 2022). This study suggests that

students are more prone to experiencing higher levels of mental fatigue with traditional learning. Another study by Saunthariya Mariappan & Norhisham Mohamad Nordin (2021) reported that 45.2% of students in online classes are mentally drained, and only 4.8% disagreed. Both studies suggest a different learning mode as a source of higher mental fatigue.

The main objective of this study is to evaluate the difference between the mental fatigue experienced by the students in the two learning modalities (traditional and online). Under this objective, the researchers aim to recognize what factors affect the mental fatigue of students, identify the significant characteristics of mental fatigue, and determine what mode of learning has a higher effect on mental fatigue.

Due to the current situation of our education in the Philippines, where students have the option to attend limited traditional learning, this study brings relevance to them. It will benefit college students to assess the mental fatigue factors and their transition to either learning mode. It will also help the people in charge of implementing education to improve the quality of learning in both formats.

This study evaluates and compares the two learning modes in the Philippines, such as traditional and online. The respondents of this study are limited to 100 college students in the Philippines that experienced both learning formats. The study will only provide a recommendation on how to lessen the mental fatigue of students in each mode of learning. Furthermore, statistical tools will be limited to ANOVA (Analysis of Variance) to analyze the differences in mental fatigue in traditional and online learning and correlation to identify the significant factors of mental fatigue.

2. Review of Related Literature

In a study on Brazil's medical students by de Oliveira Kubrusly Sobral et al. (2022), the participants' perceptions of zoom fatigue, or the fatigue experienced during or after a videoconference, are compared on problem-based teaching and a hybrid system teaching methodology. In the hybrid system, traditional teaching and PBL were both used. This study showed that 56% of students using the hybrid model experienced zoom fatigue, and 41% of students using the PBL method experienced zoom fatigue. The hybrid methodology differed from the PBL students by having a higher frequency of wanting and needing to be alone after a videoconference. This study suggests that the number of activities and the participation of the students are essential factors to be considered in assessing learning fatigue.

Students attending online classes during the COVID-19 pandemic were experiencing mental fatigue, according to Saunthariya Mariappan & Norhisham Mohamad Nordin (2021). 45.2% of the respondents reported being mentally drained after attending online classes, only 4.8% disagreed with that statement, and no student strongly disagreed with any questions indicating their mental fatigue. In the study, the amount of time spent in online classes is proportional to mental fatigue.

In another study by Sievertsen, H. H., Gino, F., & Piovesan, M. (2016), the researchers evaluate how the time of the test affects performance using test data from all children attending Danish public schools between 2009/10 and 2012/13. The school's weekly class schedule and computer availability decide the test timing. The researchers discovered that test performance drops by 0.9 percent of an SD (95 percent CI, 0.7–1.0 percent) every hour later in the day. On the other hand, a 20–30-minute break enhances average test performance by 1.7 percent of a standard deviation (95 percent confidence interval: 1.2–2.2 percent). With that result, the researchers made two critical policy implications: First, while determining the length of the school day and the frequency and duration of breaks during the day, cognitive tiredness should be taken into account. Second, school accountability systems should account for the impact of external influences on test performance.

According to the study by Fauville et al. (2021), fatigue is related to the duration of meetings, frequency of meetings, and burstiness, with the duration of meetings being the most important factor for predicting the amount of fatigue. All three measures of fatigue are positively correlated with $p < 0.001$. Women in this study have longer meetings and shorter breaks than men, therefore, experiencing more fatigue. This hypothesis was confirmed in this study that gender is related to fatigue despite the duration and burstiness of meetings being statistically controlled. Women still experienced 13.8% higher fatigue.

Male students experienced significantly lower mental fatigue than female students in the study of mental health among university students by Mosleh et al. (2022). Most of the respondents were female (78.5%). It was found that 40% of the students are satisfied with the online approach, and 45.5% of respondents perceived it reduces their home

confinement stress, but it was recommended that educational institutions should improve their preparedness for online teaching.

Moreover, the study of Smith (2018) was conducted in the Ethics Committee, School of Psychology, Cardiff University, United Kingdom. Smith stated that the well-being of the students, grade point average, and efficient studying affect the students in cognitive fatigue. The researcher data were 313 first- and second-year psychology students who took part in the study. Cardiff University students who got course credit for their participation (88.7% female; mean age: 19.5 years; age range: 18-41 years) (students from other years were not required to participate in research studies). The overall wellbeing score, GPA, course stress, and studying efficiency were used as outcomes in regressions using the mental fatigue scores and established predictors. Participants from years 1 and 2 showed similar levels of well-being and attainment and similar associations with predictors. According to Smith's research, mental fatigue is linked to a negative sense of well-being and lower academic achievement.

Furthermore, a study in China on the prevalence of fatigue among Chinese nursing students in the post-COVID-19 era by Liu S. et al. (2021) focused on the fatigue effects of nursing students; 1,070 nursing students participated. Fatigue was found in 67.3 percent of the population (95 percent confidence interval [64.4–70.0]). Multiple logistic regression analysis revealed that being a senior nursing student (second year: OR = 2.20, 95 percent CI [1.46–3.33], P 0.001; third year: OR = 3.53, 95 percent CI [2.31 5.41], P 0.001; and fourth-year OR = 3.59, 95 percent CI [2.39–5.40], P 0.001) were significantly associated with more severe fatigue (P = 0.003, OR = 1.73, 95 percent CI [1.20–2.49]).

According to Mustika et al. (2021), a study on 274 medical students at the undergraduate level found that students had moderate to strong favorable feelings regarding online learning and high positive and moderate negative emotions. Gender, year of study, and academic program all showed statistically significant variations across groups. Almost every feature of the online learning environment was strongly associated with students' happiness, personal relevance, and evaluation and assessment, the two most significant predictors (R² = 0.201; P 0.001).

A study by Podrigalo et al. (2016) concluded that mental fatigue gradually improved after the assessment during traditional classes, which was unsatisfactory to subjective feelings. Hence, it reflects an imbalance in students' workability since there are factors that could affect the productivity of students, such as complaints and over-fatigue for a self-assessment of health.

In contradiction, a study titled "Mindfulness-Based Stress Reduction (MBSR) Delivered Live on the Internet to Individuals Suffering from Mental Fatigue", is a relevant topic that focuses on the considerable effect of mental fatigue on work and social interactions. In this study, they had to use the MFS or Mental Fatigue Scale for them to conclude that there are possibilities that individuals who have a certain health condition can be affected by the mental fatigue caused by the Internet world. This could affect their social and work interactions in dealing with disability since the stress and fatigue could intervene in the learning process. (Johansson, 2015)

2. Methodology

The researchers will use ANOVA and descriptive analysis to analyze the collected data. In that way, there will be a statistical analysis using a Survey pertaining to two different learning modalities (Traditional and Online). In addition, the collection of data will be distributed online via Google Forms. Similarly, the researchers will also use MFS or the Mental Fatigue Scale for assessing fatigue gravity in students depending on their self-generated empirical data on both learning modes.

2.1 Conceptual Framework

Figure 1 shows the different factors that the researchers focus on, namely, the number of assessments a student can finish in a day. Then the difficulty of exams that a student may encounter in their different subject. Also, the duration of study that includes how long the student can study their different subject after their online and traditional learning. Finally, the GPA is the average student's grade from the last term or semester. Furthermore, according to Smith's (2018) recommendation, other researchers should find different factors that include GPA and duration of study of the students to analyze mental fatigue.

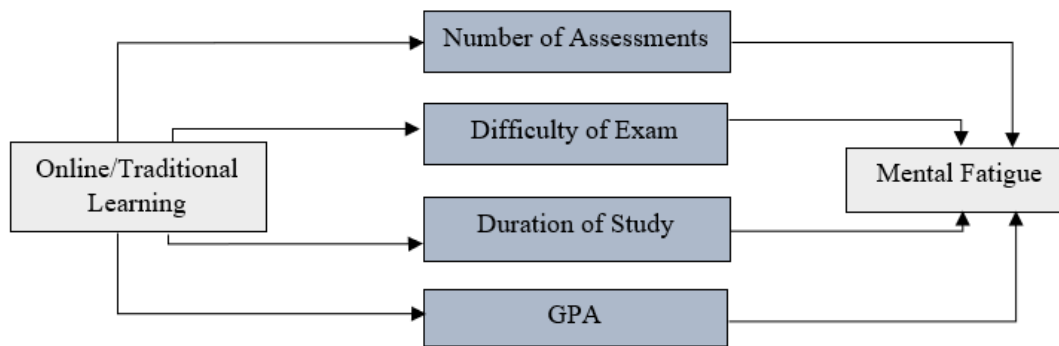


Figure 1. Conceptual Framework

2.2 Respondents of the Study

The respondents of this study are limited to those who experienced both learning modalities, and only 100 will be considered. The purposive sampling technique will be used to assess the mental fatigue of students as it is limited to college students who have experienced online and traditional learning. Questionnaires will be provided to the respondents to determine the mental fatigue of students during traditional and online learning.

2.3 Ergonomic Tools

The study used the Mental Fatigue Scale (MFS) questionnaire to determine the mental fatigue score of the students. Through this, the researchers will be able to evaluate and assess its impact of it on the working physiology of students in traditional and online learning modalities. Hence, this tool could help to generate information to add more solutions on how to lessen the burden of students' experiencing mental fatigue from both modes.

2.4 Statistical Treatment of Data

The researchers used three statistical treatments for the data. Descriptive statistics are used to summarize the respondent's demographics and profile, ANOVA is used to compare if there is any significant difference in the Mental fatigue score of college students in Traditional and Online learning, and correlation to determine the significant factors in the Mental fatigue of students in Traditional and Online. The initial hypothesis for the ANOVA is

Ho: There is no significant difference between the mode of learning and the Mental fatigue score of college students.

Ha: There is a significant difference between the learning mode and the Mental fatigue score of college students.

3. Results and Discussion

The statistical tools used are the ANOVA, Correlation, and MFS or the Mental Fatigue Scale, which identified the actual cause of mental fatigue through students who had experienced both traditional and online learning modalities. The result of this study is significant in determining the difference in both modalities. The results expose the real difference between Traditional and Online learning modes. These results are based on 100 participants.

3.1 Respondent's Profile

In doing this study, the researchers recruited 100 students to respond to given mental fatigue-related questions. There are a total of 50.5% females who answered the questionnaire and 49.9% total male respondents. Moreover, 75% are aged between 18 and 20, and 25% are 21 and above, meaning that most students are at college sophomore level. They have also experienced both modalities of learning. 86% of students reported having mental fatigue in an online format; 74% of students have mental fatigue in traditional learning. As a result, there is a relatively high possibility that both modalities affect students' mental fatigue, but online learning is much more weighed as more students are affected.

3.2 ANOVA Results

Table 1. Generalization of ANOVA Results from both Learning Modalities with the Mental Fatigue Score (MFS)

Factor	Category	Mean	Std. Dev	p-value	Remarks
Learning mode	Online	18.825	7.688	0.012	Significant
	Traditional	16.010	8.043		

The ANOVA results revealed specific factors that cause mental fatigue to students by which they can detect the difference between modalities. In this table, both modalities have significance and affect students' mental fatigue. Even though both have significance, the online learning method has a much higher mean of 18.825, meaning it has a more complicated setup. In addition, students feel that online learning was a big challenge through their assessments, hours of classes, and difficulty with concepts. Traditional learning has accumulated a lower mean of 16.010, meaning it has a much less complicated setup for the class mode. Nevertheless, both modalities have a p-value of 0.012 which means that both have caused mental stress or fatigue to students.

3.3 Mental Fatigue Scores in Traditional Learning

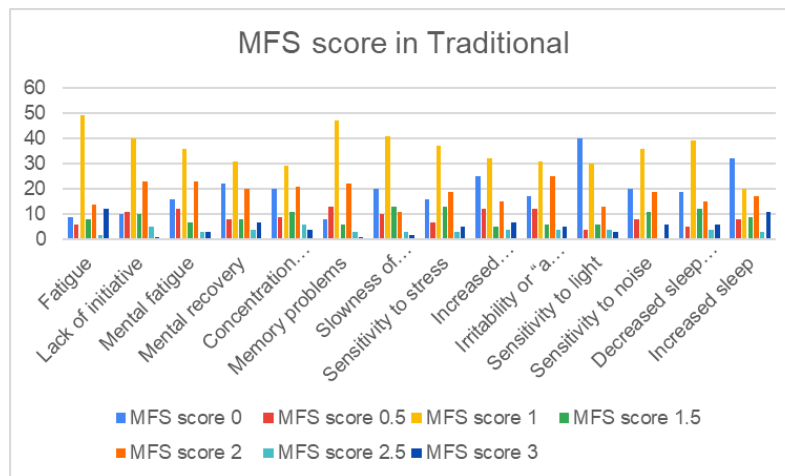


Figure 2. Summary of Mental Fatigue Scale in Traditional Learning

Figure 1 shows all the mental fatigue factors in their percentages, represented by bar graphs. The following data exposes the actual and empirical data that the respondents chose. Nevertheless, students nowadays are vulnerable to different factors. Still, this study will only focus on fatigue, lack of initiative, mental fatigue, recovery, concentration, memory problems, slowness of thinking, sensitivity to stress, increased tendency to become emotional, irritability, sensitivity to light, noise, increase and decrease of sleep. So these are the following factors that could cause students mental fatigue.

Fatigue for students means physical and mental aspects of an individual; on the questionnaire, 49% are relatively experiencing fatigue but felt alert after a rest. This means that students need rest to pursue tasks given by instructors effectively. Moreover, 40% lack initiative of 40% which means that students hardly start things that they are used to. They feel that being on a circular series of activities and initiating things to be completed is hard.

The mental fatigue of students has accumulated 36% and a recovery of 31%. This means that the recovery is much lesser than the problem. In addition, the cognitive aspects such as concentration, memory problems, and slowness of thinking had accumulated 29%, 47%, and 41%, respectively. It means that the cognitive aspects of students decreased in quality since they think they have slower thoughts to be discussed, less concentration, and a slightly manageable memory gap.

To focus on sensitivity, there are four factors that have been stated in the MFS. Stress, Light, Noise, and Sleep are the factors that pertain to sensitivity. In relation to this, sensitivity to the decrease in sleep is figured, which accumulated at 39%, which means that the decline in sleep is reflected in traditional learning. On the other hand, 37%, 30%, and 36% are the results of sensitivity to stress, light, and noise. To interpret, the highest sensitivity of all is stress related to mental fatigue, which boils down to psychological aspects. The least is the sensitivity to light, meaning that students prefer a lesser light source to a stressful and noisy environment.

For the concept of mental vulnerability, the factors of the tendency to become emotional and irritability are alluded to since these two reflect the students' reaction to the learning environment. The tendency to become emotional garnered 32%, by which students sometimes feel mentally stressed and need to cry for quite some time. Still, it is a natural phenomenon that affects the students deeply. Further, the irritability rate of students is 31%, which interprets that it is natural to be irritated but would not last for a long time.

3.4 Mental Fatigue Scores in Online Learning

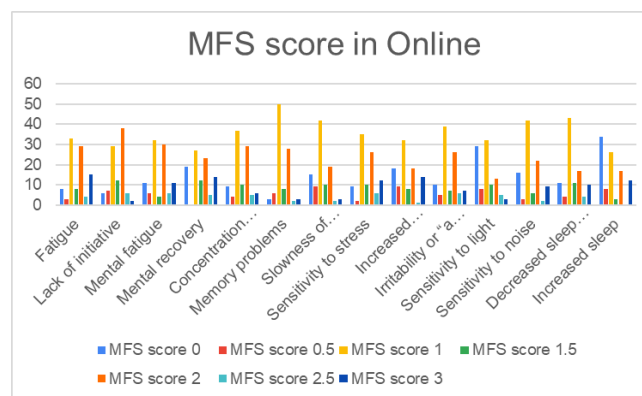


Figure 3. Summary of Mental Fatigue Scale in Online Learning

In the online learning mode, it has accumulated the highest percentages in affecting students' mental fatigue. The memory problem factor garnered 50 out of 100 participants, which means that students do have their dilemmas, but on a consensus answer, students do have short memory problems, but they can easily manage for them to cope with the tasks given. Moreover, the fatigue factor accumulated 33%, implying online learning has fewer students who consider themselves physically tired since they are studying at home.

In initiation strategies, it takes a great effort to start things. 'This applies to everyday activities such as getting out of bed, washing oneself, and eating.' This factor got 38%, meaning that most students have difficulty finding inspiration to boost initiative in completing such tasks. Moreover, mental fatigue and recovery have the same result as the traditional, but these factors got 32% and 27% less than traditional learning. The coping mechanism of students in online learning has lesser possibilities since the instructors do not appropriately assess them. As an outcome, they need at least an hour to rest to recover from a tiring schedule.

A higher percentage also manifested problems such as sensitivity to noise, sleep, and irritability. These factors garnered 42%, 43%, and 39%, respectively. This means that there is a significant effect on students experiencing a noisy environment. Also, they decrease their sleeping habits, and they feel more restless in online learning. For that reason, too much irritability causes it easy to be irritated.

3.5 Correlation

Pearson correlation is used for the determinants of significant factors affecting the mental fatigue of traditional and online college students in the Philippines. The factors considered in the study are the duration of the study, the difficulty of the exam, the number of assessments, and GPA. These factors are correlated with the total Mental fatigue score in both learning modes.

Table 2. Summary of correlation result between the factors and Mental fatigue score in online

Factors	Pearson correlation (r)	p-value	Remarks
Duration of Study	0.207	0.039	Significant
Difficulty of exam	0.183	0.069	Not significant
No. of assessments	-0.064	0.524	Not significant
GPA	0.063	0.535	Not significant

Table 3. Summary of correlation result between the factors and Mental fatigue score in traditional

Factors	Pearson correlation (r)	p-value	Remarks
Duration of Study	-0.018	0.862	Not significant
Difficulty of exam	0.058	0.568	Not significant
No. of assessments	-0.150	0.135	Not significant
GPA	-0.117	0.246	Not significant

In Table 2, only the factor Duration of study significantly affects the Mental Fatigue Score of students with a Pearson correlation of 0.207 and a p-value of 0.039, and none of the other factors are significant in an online setup. In Table 3, none of the factors are significant. The results of their p-value are greater than the alpha of 0.05. Comparing the correlation result, only the duration of study in online classes significantly affects mental fatigue.

4. Conclusion

In this study, the researchers gathered data from 100 respondents of college students in different schools in the Philippines, and the mental fatigue scale was used to determine the level of mental fatigue of the respondents. Also, the researchers determine and compare the factors such as the number of assessments that can student finish within the day, the difficulty of exams in different subjects/courses, duration of the study of the student, and the GPA of the student last term/semester. The survey received 50.5 percent female responses and 49.9 percent male responses. Furthermore, 75% of the students are between the ages of 18 and 20, and 25% are between the ages of 21 and 25, indicating that most of the students are in their sophomore year of college and have had exposure to both modes of learning. In an online format, 86 percent of students expressed mental fatigue; in a traditional version, 74 percent of students reported mental fatigue. As a result, both modalities have a reasonable chance of affecting students' mental fatigue in statistical analysis. Still, online learning is considerably more significant because more individuals were involved, and based on the ANOVA results, the online format has a mean of 18.825 and 16.010 in the traditional format. In correlation, the only significant factor was the duration of study in the online class. Students' mental fatigue is proportional to their duration of online study.

5. Recommendation

Based on the researcher's result, we recommend that future researchers explore the different factors that affect students on mental fatigue. Also, the researcher advises adding more respondents for the data to be more accurate in comparing the result of which learning modalities affect the most students in mental fatigue. Moreover, the researchers can study the different students, not only the college students but also the high school and elementary students.

For students, the researchers recommend taking a rest and doing the assessment early or in advance before the deadline to lessen mental fatigue. It is suggested that time spent on leisure, other activities, and academic responsibilities, be well managed. Using an application, for example, that displays the schedule, and due date could make work easier to manage and prioritize.

For institutions, it is advised that the school adjusts the distribution of major and minor courses loaded on each student per term. According to the findings, the stress in schoolwork, light sources in the house, and noise in the study area increase a student's mental fatigue level. This indicates that students' mental fatigue is linked to their physical health. Furthermore, the findings revealed that a student's typical study hours considerably impact their level of mental fatigue. In theory, a student's average study hours are related to the units in their program. As a result, if the student's task is distributed differently, the study hours will also alter.

References

- Boksem, M. A., & Tops, M. (2008). Mental fatigue: costs and benefits. *Brain research reviews*, 59(1), 125-139. <https://doi.org/10.1016/j.brainresrev.2008.07.001>
- de Oliveira Kubrusly Sobral, J. B., Lima, D. L. F., Lima Rocha, H. A., de Brito, E. S., Duarte, L. H. G., Bento, L. B. B., & Kubrusly, M. (2022). Active methodologies association with online learning fatigue among medical students. *BMC Medical Education*, 22(1). <https://doi.org/10.1186/s12909-022-03143-x>
- Fauville, G., Luo, M., Queiroz, A. C. M., Bailenson, J. N., & Hancock, J. (2021). Nonverbal Mechanisms Predict Zoom Fatigue and Explain Why Women Experience Higher Levels than Men. *SSRN Electronic Journal*. <https://doi.org/10.2139/ssrn.3820035>
- Hannay, M., & Newvine, T. (2006). PERCEPTIONS OF DISTANCE LEARNING: A COMPARISON OF ONLINE AND TRADITIONAL LEARNING. *MERLOT Journal of Online Learning and Teaching*, 2(1). <https://jolt.merlot.org/documents/MS05011.pdf>
- Interconnections of Mental Workability of Students*. <https://www.researchgate.net/profile/Walery-Zukow/publication/312020775>
- Johansson, B., Bjuhr, H., Karlsson, M., Karlsson, J., & Ronnback, L. (2015). *Mindfulness-Based Stress Reduction (MBSR) Delivered Live on the Internet to Individuals Suffering from Mental Fatigue After an Acquired Brain Injury*. SpringerLink. <https://link.springer.com/article/10.1007/s12671-015-0406>
- Liu, S., Xi, H. T., Zhu, Q. Q., Ji, M., Zhang, H., Yang, B. X., ... & Xiang, Y. T. (2021). The prevalence of fatigue among Chinese nursing students in post-COVID-19 era. *PeerJ*, 9. <https://doi.org/10.7717/peerj.11154>
- Mosleh, S. M., Shudifat, R. M., Dalky, H. F., Almalik, M. M., & Alnajar, M. K. (2022). Mental health, learning behaviour and perceived fatigue among university students during the COVID-19 outbreak: a cross-sectional multicentric study in the UAE. *BMC Psychology*, 10(1). <https://doi.org/10.1186/s40359-022-00758-z>
- Mustika, R., Yo, E. C., Faruqi, M., & Zhuhra, R. T. (2021). Evaluating the Relationship Between Online Learning Environment and Medical Students' Wellbeing During COVID-19 Pandemic. *The Malaysian Journal of Medical Sciences: MJMS*, 28(5), 108. <https://dx.doi.org/10.21315%2Fmjms2021.28.5.11>
- Podrigalo, L., Iermakov, S., Rovnaya, O., Zukov, W., & Nosko, M. (2016). Assessment of mental workability indicators. *Peculiar Features between the Studied Indicators of the Dynamic and*
- Saunthariya Mariappan, & Norhisham Mohamad Nordin. (2021). Physical, Mental, and Emotional Fatigue Experienced by IT Students During Covid-19 Pandemic. *Journal of ICT in Education*, 8(3), 100–116. <https://ojs.upsu.edu.my/index.php/JICTIE/article/view/6181>
- Sievertsen, H. H., Gino, F., & Piovesan, M. (2016). Cognitive fatigue influences students' performance on standardized tests. *Proceedings of the National Academy of Sciences*, 113(10), 2621-2624. <https://doi.org/10.1073/pnas.1516947113>
- Smith, A. P. (2018). *Cognitive fatigue and the well-being and academic attainment of university students*. *Journal of Education, Society and Behavioral Science*. <https://doi.org/10.9734/JESBS/2018/39529>

Biographies

Virlix Claire A. Estandian is a second-year college student at Mapua University, School of Industrial Engineering and Engineering Management, Intramuros, Manila. She is taking up a Bachelor of Science in Industrial Engineering.

Robin D. Torres is a second-year college student at Mapua University, School of Industrial Engineering and Engineering Management, Intramuros, Manila. He is taking up a Bachelor of Science in Industrial Engineering.

Marc Christian C. Reyes is a second-year college student at Mapua University, School of Industrial Engineering and Engineering Management, Intramuros, Manila. He is taking up a Bachelor of Science in Industrial Engineering.

Ma. Janice J. Gumasing is a Professor at the School of Industrial Engineering and Engineering Management at Mapua University, Philippines. She has earned her B.S. degree in Industrial Engineering and a Master of Engineering degree from Mapua University. She is a Professional Industrial Engineer (PIE) with over 15 years of experience. She is also a professional consultant of Kaizen Management Systems, Inc. She has taught courses in Ergonomics and Human Factors, Cognitive Engineering, Methods Engineering, Occupational Safety and Health, and Lean Manufacturing. She has numerous international research publications in Human Factors and Ergonomics.