A Case Study of Perceived Effect of Thermal Comfort to the Mental Fatigue Level of Students during Online Class

Matthew P. Solivio, Deceree Anne A. Haboy, Kirstien Paola E. Robas and Ma. Janice J. Gumasing
School of Industrial Engineering and Engineering Management
Mapua University
Intramuros, Manila, Philippines
daahaboy@mymail.mapua@edu.ph, kperobas@mymail.mapua.edu.ph,
mpsolivio@mymail.mapua.edu.ph, mjjgumasing@mapua.edu.ph

Abstract

As the Coronavirus disease (COVID-19) took away the accustomed routines of the people, the prevalence of online platforms in present times became more evident as every field or industry opt to adapt to the new normal. With that, education was never excluded from the said adaptation. As schooling cannot be hindered, the educational system transitioned from having a face-to-face method to conducting online classes for a safer and more convenient learning experience. However, this adaptation did not solely bring convenience as numerous students and teachers encounter different challenges, and one of these is the condition of the available workplace. Several studies have proven that the environment of the area of work must always assure comfortability as this can impact an individual's mental fatigue and cognitive performance. As the temperature is among the said factors, the researchers aimed to determine the perceived effect of the thermal comfort and measured temperature level on the students' mental fatigue. Upon the evaluation of gathered data and application of statistical tools using ANOVA and correlation analysis, it proved that thermal comfort experienced by students during online class varies based on the time of the study (morning, afternoon, and evening) and based on the source of ventilation (fan, A/C units and multiple sources of ventilation). Results also showed that thermal comfort indeed plays a pivotal role in the mental fatigue of students. it depicted that measured temperature level of students during online class has a direct relationship to the mental fatigue of students specifically on dimensions such as Concentration Difficulty ($r=0.482$, $p<0.001$) Irritability ($r=0.813$, $p<0.001$), Unproductivity ($r=0.402$, $p<0.001$), and Mental Recovery from high temperature ($r=0.661$, $p<0.001$).

Keywords
Temperature, mental fatigue, online learning, thermal comfort

1. Introduction

1.1. Background of the Study

Over the past decades, the continuous advancement of technology brought an overwhelming response from people globally. The unceasing progression of technology has built bridges towards efficiency and convenience, may it be for communication, education, business, and others. This concept has cultivated several disputes and perceptions. However, despite the disadvantages it bears, it could not outweigh the dominance of its benefits. As every individual act as the prime beneficiary of the said development, the undeniable reliance on technology and the internet is very evident. With that, the world tends to face every challenge having technology as both their main weapon and shield. In the year 2020, a virus deprived the world of its freedom and safety. Coronavirus disease is a new infectious disease that has been taking over globally. The said phenomenon has shocked and stunned people as it took away their normal routines. This pandemic paved the way to the maximization of the use of online platforms as it is the safest way to continue what has been started before encountering this pandemic. These online platforms helped in reducing the hindrance for different industries, as well as education.

Even so, there are still challenges that are yet to be addressed in coping with the new normal. As the pandemic forced the transitioning of education to online learning, a lot of people encounter difficulties with the new education system. Availability of technology and lack of access to resources is the most common hindrances. However, it is often forgotten that another challenge that needs to be heeded is the unpreparedness of the workplace. Despite the

adjustments made, numerous people still questioned the effectiveness of online learning not only because of the teaching method or approach but also because of the condition of the workplace available. Several studies claimed that the workplace environment influences an individual's competency. It is proven that a conducive workplace promotes a healthy environment that heeds human comfort to increase productivity and takes good care of a person's welfare (Awan & Tahir, 2015). This involves the relationship of the environment, which includes the equipment, noise, lighting, and temperature, to human comfort. As the conducive workplace is considered an indoor environment, one of its fundamental characteristics is the indoor temperature. Therefore, this variable is one of the factors to be considered in assessing human comfort for it influences both health and work rate (Fisk, Lei, & Seppanen, 2006). In the same article, it stated that there is a relationship between temperature and performance. However, the study excluded the impacts of temperature on humans' mental fatigue. Similar to temperature, mental fatigue was proven to decrease productivity by negatively affecting cognitive performances such as executive attention, which refers to the regulation of response, and goal-directed attention, which refers to the preparedness in responding (Tanaka, Ishii, & Watanabe, 2015). With that, this study will focus on understanding the relationship between temperature and mental fatigue for further understanding of how it affects a person's cognition. There may be existing studies that focus on the relationship between mental fatigue and performance as well as temperature and performance, however, there were no studies that dealt with the impacts of temperature on mental fatigue.

1.2. Review of Literature Review

Globally, as people face the pandemic, at least 1.2 billion students among 186 countries are affected by the school shutdown (Li & Lalani, 2020). With that, taking safety and convenience into account, the education system was forced to change the conventional method and was switched to e-learning. E-learning is a learning approach or system which utilizes electronic resources and devices (Lawless, 2018). Adaptation of the said approach is very prevalent as it brings advantages the old system cannot provide. According to Zambito (2020), the top benefits e-learning bears are flexibility, enjoyment, and numerous opportunities. However, not all students are privileged to adapt to the new system due to several factors. An article written by Kumar (2015) discussed the different challenges faced by students in adopting e-learning. With the sudden change, a lot of problems are experienced by people that include the adaptability struggle, technical issues, computer literacy, time management, and self-motivation.

The unpreparedness of everyone is the biggest challenge one has to face. As previously mentioned, numerous problems are encountered by individuals as the new setup began. And these include the availability of the workspace. Some people may overlook its importance, but quality and good workspace ambiance were proven to lessen the stress being dealt with by a person. According to an article written by Ernst (2020), 46% of workers or professionals claim that their workplaces greatly impact their work rate and productivity. Professionals always state that loud intermittent noise affects cognitive performance negatively (Abdulgafar, 2020). For lighting, it is often said that proper lighting can improve one's mood, energy, alertness, and productivity (Luenendonk, 2019). In addition, productivity and self-motivation are often associated with another. Given that education has a new environment, motivation and productivity are also affected. People normally have a hard time finding motivation for they feel tired and drained. These feelings are often associated with mental fatigue (Nazish, 2018). With that, a conducive workspace must always be given importance since it is proven to increase the morale of a worker thus improves productivity. In addition, a study stated that a sound-proofed, well-lit, and well-ventilated room prevents interruptions and promotes comfortability and calmness to workers (Kohll, 2019).

On the other hand, different industries give much importance and observance to the temperature level as it can lead to several heat-related illnesses (Habas, 2021). Whether working indoor or outdoor, people always prioritize taking frequent breaks and observe hydration to prevent serious complications due to the temperature. According to Singh (2018), a new study concluded that extreme temperature could lead to global economic losses as workers experiencing high temperature are proven to be less productive. Thus, temperature levels put serious global problems at risk. In addition, it also stated that temperature level is the most common reason for both physical and mental exhaustion. As this causes exhaustion, it also leads to mental fatigue.

Considering the aforementioned, dealing with the temperature level must always be taken seriously. Indeed, the temperature affects not only an individual's productivity but also causes mental fatigue. A study conducted by Smith (2018), concluded that mental fatigue causes poor mental well-being and reduces the academic attainment of a person. According to Hancock, Ross, and Szalma (2007), analysis confirmed a substantial negative effect on performance associated with thermal stressors. The overall effect size for heat was comparable to that for cold. Cognitive performance was least affected by thermal stressors, whereas both psychomotor and perceptual task performance was

degraded to a greater degree. Other variables were identified that moderated thermal effects. On the other hand, based on the study conducted by Chatzidiakou, Mumovic, and Dockrell (2014), there is evidence that lower temperatures in the range between 25C to 20C improved student performance by 2% to 4% for every 1C reduction. Therefore, temperature level affects mental fatigue and cognitive performance.

1.3. The gap of Missing Information

The relationship between indoor temperature, thermal comfort, and learning performance was dealt with in the study of Jiang, Wang, Liu, Y., Di, and Liu, J. entitled *A holistic approach to the evaluation of the indoor temperature based on thermal comfort and learning performance* in 2021. In their study, they considered pupils studying in provinces of northwestern China, where droughts and low rainfall exist. Their evaluation of the learning performance also considered the source of ventilation in the classrooms and the background air velocity. Upon evaluating twelve (12) Chinese pupils, they concluded that students perform better in classrooms with slightly cooler temperatures, and temperature readings that are higher or lower reduce the performance and productivity (Jiang et al., 2021). Therefore, it proves that there is a relationship between an individual's cognitive performance and indoor temperature. However, their study was only limited to the pupils studying in China, and samples were observed in air-conditioned classrooms with a high density of students. Thus, the current study will deal with the perceived effect of temperature level on the mental fatigue level of students who are experiencing online classes. As the previous study considered classrooms as their working environment, this research will consider indoor temperature from houses. Moreover, different factors considered in this study are the source/s of ventilation, time of the study, and area of study.

1.4. Objectives

The main objective of this study is to determine the impacts of temperature level on the mental fatigue of students during online classes. The specific objectives of this study are as follows: (1) to determine the temperature level of students' work during their online classes and to assess the heat stress category being dealt with during online classes; (2) to enumerate the factors that affect the temperature level; (3) and to determine the different effects of temperature to the mental fatigue of the respondents.

1.5. Significance of the Study

As this study brings relevance to the current situation, it can be beneficial for the students themselves as this can help them understand the relationship of temperature to their mental fatigue or health, and can serve as their guide in improving their current workstations for better comprehension in schooling. It can also benefit designers, engineers, and architects to construct buildings or structures that will consider recommended room temperature to reduce or balance thermal stress. Lastly, the relevant information and findings of this research for this study can help future similar studies as this can be used as their related literature.

1.6. Scope and Limitation

This research focused on identifying the possible impacts and effects of temperature level on the mental fatigue of students during online classes. A survey was conducted to gather data that were used in the formulation of conclusions and recommendations. Respondents will be limited to one hundred (100) College students taking up online classes in the Philippines. Furthermore, the study will only provide recommendations that will help reduce the thermal stress experienced by the respondents but will not provide a sample workplace design. Statistical tools will only be limited to Analysis of Variance (ANOVA), Tukey's Post hoc Test, and Correlation Analysis.

2. Methods

The study is correlational research that aims to establish the relationship between Temperature and Mental Fatigue by determining associations, similarities, and effects between the two variables. Initially, the researchers collected essential data specifically the Mental Fatigue Score and the Room Temperature by a survey questionnaire. The purpose of the questionnaire is to assess certain dimensions or aspects of a person's mental capability or condition concerning temperature. This includes lack of initiative, concentration difficulty, memory problems, mental fatigue, irritability, sensitivity to stress, unproductivity, and mental recovery. Each dimension excluding memory problem, concentration difficulty, and unproductivity is followed by four statements that describe the following: No Effect (0), Slight Affected (1), Fairly Serious (2), and Serious (3). On the other hand, the excluded dimensions are also followed by four statements that describe the following: No Effect (1), Affected due to High Temperature (2), Affect due to Low Temperature (3), Affect but neither caused by High or Low Temperature (4). The survey also requested the respondents to enumerate the sources of ventilation available, the room temperature, and their desired time and place

to study. After gathering data, the researchers applied statistical treatments to better understand the relationship between the said variables.

2.1. Respondents of the Study

The respondents considered one hundred (100) college students that are currently taking online classes in the Philippines. The sampling technique used in this study is purposive sampling as the researchers assessed the mental fatigue of those students who are currently taking college education. The study provided questionnaires that will determine the temperature level of the students' work and determine its effects on respondents' mental fatigue.

2.2. Ergonomic Tools

This study applied the concept of temperature in the physical work environment of a person. The use of a temperature measuring device allowed the researchers to collect the room temperature of the respondents as well as the mental fatigue score of the participants through a survey questionnaire. With this, the researchers were able to assess the thermal comfort of the respondents as well as the impacts of temperature on a person's mental fatigue. It also enabled the researchers to identify the Heat Stress Category of the respondents. Through this, the researchers were able to provide details on whether the subjects are in good and safe conditions in terms of performing physical activities at certain temperatures and duration.

2.3. Statistical Treatment of Data

The study also used statistical treatment to evaluate the relationship among the data collected. Descriptive statistics were used to evaluate the respondents' profile and the Mental Fatigue Score to identify which among the dimensions included has the highest and lowest Mental Fatigue Score. A bar graph was also provided to better understand the frequency of the dimensions. Also, part of the descriptive statistics is to analyze the heat stress category being dealt with by students during online classes. Moreover, Analysis of Variance (ANOVA) was used to compare the thermal comfort to factors such as time of day, area of study, and source of ventilation. This was included for the researchers to hypothesize that these factors vary in terms of thermal comfort experienced by students during an online class. The initial hypothesis of the ANOVA states that there is no significant difference in the thermal comfort of respondents based on the said factors. Specifically, three ANOVA Tests were executed in the study as follows:

Ho: there is no significant difference in the thermal comfort of students based on time of study
Ha: there is a significant difference in the thermal comfort of students based on time of study
Ho: there is no significant difference in the thermal comfort of students based on the area of study
Ha: there is a significant difference in the thermal comfort of students based on the area of study
Ho: there is no significant difference in the thermal comfort of students based on sources/s of ventilation
Ha: there is a significant difference in the thermal comfort of students based on sources/s of ventilation

The first ANOVA focuses on the difference between thermal comfort and the time the participants take their online classes. The data used in this ANOVA Test is the comfortability score of the respondents or the level of comfort while doing online classes. Subsequently, the second ANOVA Test focuses on whether the area where the participant's study resulted in the difference in thermal comfort. The last ANOVA Test focuses on the source of ventilation's significant impact on the thermal comfort of the participants. Through ANOVA Statistics, the researchers were able to evaluate whether these factors have a significant effect on a person's thermal comfort by evaluating the p-value. If the obtained p-value is less than 0.05, therefore there is a significant difference thus rejects the null hypothesis, otherwise not significant.

Afterward, the data underwent a Tukey's Post Hoc Test for the identification of significant differences among factors. A Tukey's Post Hoc Test compares the means of all the factors to the mean of every other factor or treatment. Each ANOVA Test that resulted to have a significant difference was paired with Tukey's test. Then, a Correlation test was done to determine the relationship between thermal comfort to the Mental Fatigue Score. The data used in this test is the room temperature of the respondents and the dimensions (*i.e., Lack of Initiative, Concentration Difficulty, and Memory Problem*) included in the study. This method helped the researchers to identify which among the dimensions is correlated to thermal comfort, or which among these have an effect on the room temperature. In the correlation test, two results were acquired, the Pearson Correlation Coefficient and the P-value. For the Pearson Correlation Coefficient, a value close to positive or negative 1 states that there is a perfect correlation between the variables. On the other hand, if the Pearson Correlation Coefficient lies between 0.50 and 1, then it has a medium correlation, while a Pearson Correlation Coefficient that lies below 0.29 means that it has a small correlation. However, if the value is close to 0, there is no correlation between the variables.

3. Results and Discussion

The use of statistical treatments such as ANOVA and Tukey's Test helped the researchers explain the relationship of temperature to the identified factors. The study gathered data by providing a questionnaire that examined the Mental Fatigue Score of the participants. As seen in Table 1, the sample comprised of one hundred (100) participants was equally divided into male and female genders. The study did not cover the relationship of gender to thermal comfort since there are existing studies that established the correlation between gender and thermal comfort. It is already proven that females are more thermally sensitive than males especially when exposed to cooler temperatures (Karjalainen, 2011). As mentioned earlier, the respondents were college students divided into four (4) year levels.

3.1. Result of ANOVA

As previously stated, it is essential to apply the ANOVA test to identify the relationship between thermal comfort and the aforementioned factors. The first ANOVA Test focused on the temperature and time of day. In this case, the null hypothesis of the researchers states that there is no significant difference in the thermal comfort of respondents based on the time of the study. As can be seen in figure 2, the interval plot displays the difference in variance based on the height of each point. As observed, the height of the variables is almost the same, therefore there is an equal variance among the variables. The variables must have almost equal variance as it indicates that the variables are comparable. This means that it is possible to undergo an ANOVA Test. It also shows whether the thermal comfort of the respondents is significantly different based on their usual time of the study. If there are overlapping groups in the interval plot, this indicates that there is no significant difference between those variables. In this case, the majority of the respondents have significantly higher thermal comfort during the evening.

Table 1. Summary of ANOVA Result

Factors	Variable	Mean	Std. Dev.	p-value	Remarks
Time of Day	Morning	3.000	1.054	0.005	Significant
	Afternoon	3.100	0.738		
	Evening	4.200	0.632		
Area of Study	Bedroom	3.857	0.949	0.268	Not Significant
	Living Room	3.357	0.842		
	Others	3.786	0.802		
Source of ventilation	Air conditioner	4.667	0.707	0.000	Significant
	Electric Fan	3.000	0.707		
	Multiple	4.333	0.500		

Since there is a significant difference between these variables, a Tukey's Post Hoc Test was applied to further understand where the difference from each category lies. If the comparison passes through a value of 0, it indicates that is no significant difference between the factors. Factor Evening has a significant difference to both Morning and Afternoon. This explains why the mean of factor Evening is larger compared to the other factors. This proves that students have significantly higher thermal comfort during the evening.

Similarly, the researchers also considered the relationship between thermal comfort and the area of study. For the second ANOVA Test, the null hypothesis states that there is no significant difference in the thermal comfort of respondents based on the area of study. Before all else, an interval plot determined whether the data should undergo an ANOVA Test. As seen in figure 4, there is a similarity with the height of the factors, thus shows that there is an equal variance among the factors. This depicts that the data is suitable to go through an ANOVA Test. In addition, it can be observed that all of the factors have overlapping points, thus creates an initial analysis that these factors have no significant impact on thermal comfort.

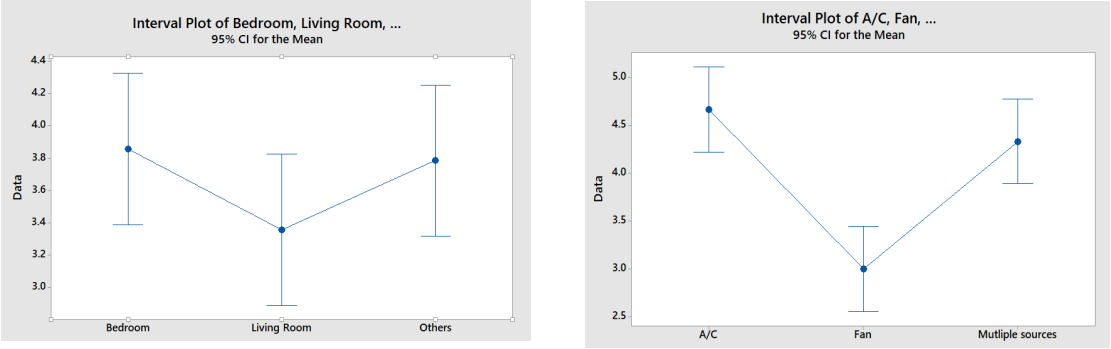

Figure 1. Interval Plot of Thermal Comfort based on Area of Study and Source of Ventilation

Despite the initial analysis, an ANOVA Test was still used to further support the claim based on the interval plot found in figure 4. As seen in Table 2, the p-value of the factor area of study is 0.268. Since the computed p-value is higher than 0.05, the null hypothesis must be accepted. This result supported the initial analysis that there is no significant difference between the area of study and thermal comfort. With that, the analysis should not proceed with Tukey's Post Hoc Test. Furthermore, the researchers assessed whether there is a significant difference in the thermal comfort of the respondents based on the source of ventilation. For this ANOVA Test, the null hypothesis stated that there is no significant difference in the thermal comfort of respondents based on the source of ventilation.

Following the results of the ANOVA test, the researchers investigated whether temperature and Mental Fatigue can be correlated with one another. To achieve this, the researchers measured the Mental Fatigue Score (MFS) of the respondents and computed for the frequency to formulate an analysis. The dimensions included are the *Lack of Initiative, Concentration Difficulty, Memory Problem, Mental Fatigue, Irritability, Sensitivity to Stress, Unproductivity, and Mental Recovery in both high and low temperature*s. The researchers computed the mean and standard deviation of the data gathered and constructed a bar graph in Figure 2 that shows the frequency of the Mental Fatigue Score.

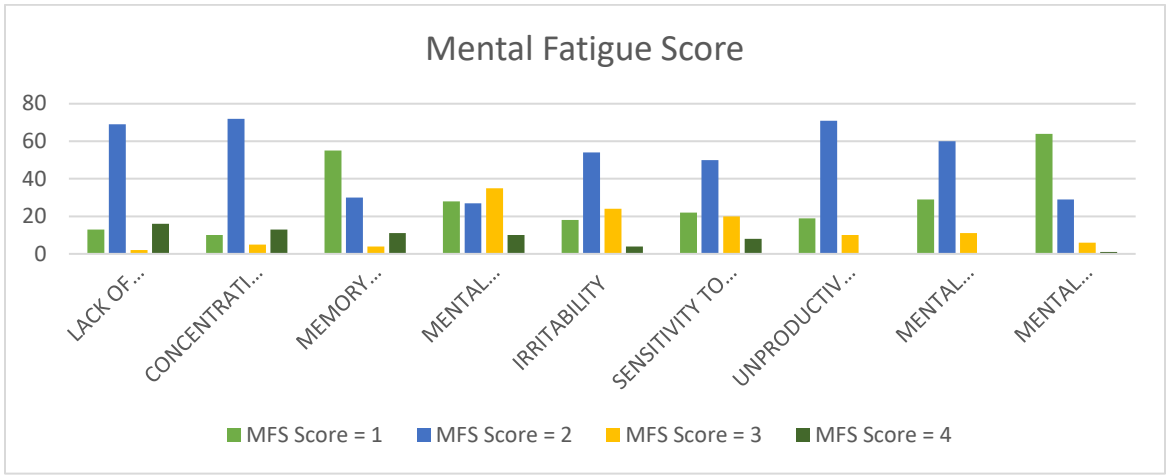

Figure 2. Mental Fatigue Score Frequency on Each Dimension

Evaluating the Mental Fatigue Score of the respondents, based on table 3 and figure 7, the majority of the respondents (69%) have an MFS score of 2 which indicates that they find it difficult to start things due to high temperature. This explains why the mean under the dimension of Lack of Initiative is equal to 2.21 since most of the respondents chose option B. On the other hand, 72% of the respondents have an MFS score of 2 under the dimension of Concentration Difficulty. This states that the respondents find it difficult to focus on things due to high temperature which also explains why the average score under this dimension is 2.21. For the next dimension, a total of 55% of the subjects have an MFS equivalent to 1 which means that they have no problem remembering things. This may indicate that

temperature has little-to-no impact on a person's memory problem. Furthermore, 35% of the respondents stated that due to temperature, they experience fatigued quickly and have to take a break from what they are doing. It is evident that on this dimension, the data are close to one another since the average MFS is 2.7, and those who had an MFS of 1 are 28% of the respondents. This states that they do not find temperature as a factor that affects their mental capability. Moreover, a majority of 54% of the respondents believe that due to temperature, they are easily irritated hence also affects their concentration. As seen in figure 7, half (50%) of the respondents have an MFS of 2 which means that due to temperature they become more easily stress but can still manage to cope up. For unproductivity, 71% of the respondents have an MFS of 2 which indicates that most of the subjects find themselves unproductive due to high temperature. The dimension of mental recovery is divided into two bases, the first one is due to a high temperature while the other is due to a low temperature. With this, the researchers were able to determine which among these two conditions makes it difficult for a person to mentally recover. Also, 60% of the respondents have an MFS of 2 which states that there is a need to rest for more than an hour before resuming a certain task. On contrary, during low or cold temperatures, 64% of the respondents believe that they only need to rest for less than an hour before resuming their tasks. However, the Correlation Test helped in assessing whether these analyses support the claims.

To reinforce the analysis on the frequency of the Mental Fatigue Score, a Correlation Test was conducted. The Correlation Test determined whether the factors seen in Table 4 have a relationship with Room Temperature. Also, the computed p-value helped in determining whether there is a significant difference or not. The null hypothesis for the Correlation Test states that there is no correlation between Room Temperature and Mental Fatigue Score. If the p-value resulted in less than 0.05, then the null hypothesis must be rejected. As seen in Table 4, the factor Lack of Initiative has a Pearson Correlation of 0.083 which is close to 0, thus there is no correlation between the Room Temperature and this factor. Next is the Concentration Difficulty wherein the computed Pearson Correlation is 0.482, since the value lies between 0.30 and 0.49, this means that there is a moderate degree of correlation between this factor and the Room Temperature. Also, the computed p-value is 0, therefore we reject the null hypothesis. This means that Concentration Difficulty and Room Temperature affect one another. As mentioned earlier, 55% of the respondents believed that Memory Problem and Temperature does not correlate. Based on the results of the Correlation Test, the Pearson Correlation is 0.029 which is close to 0. This means that the result of the test supports the claim of the respondents. This concludes that Temperature has little to no effect on Memory Difficulty.

Table 4. Summary of Correlation Result between Room Temperature and Mental Fatigue Scores

Factors	Pearson Correlation (r)	p-value	Remarks
Lack of Initiative	0.083	0.414	not significant
Concentration Difficulty	0.482	0.000	significant
Memory Problem	0.029	0.772	not significant
Mental Fatigue	0.077	0.445	not significant
Irritability	0.813	0.000	significant
Sensitivity to stress	-0.019	0.851	not significant
Unproductivity	0.402	0.000	significant
Mental recovery (hot)	0.661	0.000	significant
Mental recovery (cold)	-0.036	0.724	not significant

On contrary, the p-value of the factor Irritability is 0 which means the null hypothesis is rejected, thus shows that there is a correlation between this factor and the Room Temperature. Previously, the frequency graph, as seen in figure 7, it indicated that the majority of the respondents answered that temperature influences their Sensitivity to Stress. However, the Correlation Test proves that there is no correlation between the said variables since the p-value is greater than 0.05 and the Pearson Correlation is close to 0. On the other hand, the Pearson Correlation of the factor Unproductivity indicates that there is a moderate correlation between this factor and the Room Temperature. The p-value also supports this claim since it is less than 0.05. Lastly, the factor of Mental Recovery was divided into two conditions: (1) recovery from a high temperature (2) recovery from a cold temperature. Based on table 4, it is evident that when the temperature is low, there is no correlation between Temperature and Mental Recovery, but when the temperature is high, there is a significant difference since the p-value is 0, and the Pearson Correlation factor lies between 0.5 and 1 which indicates a high degree of correlation.

The statistical treatment applied to the data has established relationships among the variables. The study has proven that there is a significant difference in the thermal comfort of the respondents based on the time of study and the

sources of ventilation available. The data indicated that the respondents preferably would like to study during the evening since they are more thermally comfortable during this time of the day. The ANOVA test and Tukey's Test also supported that the respondents' thermal comfort is significantly higher during the evening than the other choices. For the sources of ventilation, it was also proven that the thermal comfort of the respondents is significantly different when they own a fan. In comparison, it is evident that there is no significant difference in the thermal comfort of the respondents based on the area of study. In addition, one of the objectives of the study is to understand the relationship of temperature to Mental Fatigue. Through the Correlation Test, the researchers were able to determine which among the dimensions can have an impact on the temperature. The researchers specifically determined that only the dimensions Concentration Difficulty, Irritability, Unproductivity, and Mental Recovery from a high temperature correlate with temperature.

4. Conclusion

The ongoing pandemic brought numerous challenges to everyone. These include the sudden transition of traditional learning to online education. Even though people continuously find ways to adapt to current conditions, there are essential elements that should be acknowledged as they try to perceive and survive this pandemic. One of the most significant occurring changes is the adjustment in the working environment. As mentioned earlier, it is very important to heed the state of the working area as it has a significant effect on productivity and motivation (Ernst, 2020). Through further exploration, the researchers found out that temperature influences productivity and the cognitive performance of a person (Fisk, Lei, & Seppanen, 2006). Despite the existing studies, there is a lack of understanding regarding the relationship between temperature and Mental Fatigue. The researchers believed that it is essential to establish this relationship for it can help determine the factors that can lead to mental fatigue.

With that being said, the study focused on understanding the relationship between temperature and Mental Fatigue through evaluating the Mental Fatigue Score of the respondents. As the researchers analyzed the gathered data, they found out that most participants believed that the sources of ventilation found in the area of study are sufficient enough to adjust to their thermal comfort. Despite that, the researchers identified their Heat Stress Category to assess whether the respondents are in good condition depending on the room temperature. The researchers found out that the average room temperature equivalent to 28.15 degrees Celsius is under the Yellow category. It was stated that the workers should be only exposed to this temperature for 40 minutes and should have a rest of 20 minutes. Even if the conditions are met, it is still advisable to reduce the temperature for the well-being of the workers. Moreover, the researchers also found out that 63% of the respondents prefer to study in the bedroom and chose to study during the evening. Furthermore, the study used statistical treatments specifically ANOVA Test and Tukey's Post Hoc Test to determine whether factors such as the source of ventilation, time, and area of study have an impact on thermal comfort. The results showed that 2 out of 3 factors have a significant difference in thermal comfort. The researchers found out that students who study in the evening have a higher thermal comfort compared to those who prefer during the morning or afternoon. Results also showed that there is a difference in thermal comfort based on the source of ventilation. On the contrary, the researchers also found out that there is no significant difference between the thermal comfort of the respondents based on the area of study.

As the researchers gathered the Mental Fatigue Scores of respondents, they were able to determine which among the dimensions have correlations with temperature using a Correlation Test. The researchers were able to specify that the dimensions *Concentration Difficulty, Irritability, Unproductivity, and Mental Recovery from high temperature* can be associated with temperature. Overall, the study was able to establish that there is a relationship between temperature and Mental Fatigue, thus means that it is important to ensure that the room temperature of the workplace is appropriate and comfortable, for better productivity and cognitive performance during online classes.

The researchers recommend that future studies fill the gaps of the existing researches. For better and more accurate results, the temperature of the respondents should be measured using an appropriate temperature device, as the researchers of this paper had limited equipment. This can help the researchers to formulate more precise conclusions and bases. Other factors that can affect the temperature (*i.e. size of the room, number of people staying in the same room, etc.)* must also be considered in determining the effects of temperature level on the mental fatigue of the students. Other educational levels should also be considered for their respondents for a more extensive scope.

References

Abdulgafar, T. (2020). *How Background Noise Affects Productivity*. https://krisp.ai/blog/background-noise-and-productivity/

Awan, A., & Tahir, M. (2015). Impact of working environment on employee's productivity: A case study of Banks and Insurance Companies in Pakistan. European Journal of Business and Management, 7, 329-347.

Chatzidiakou, L., Mumovic, D., & Dockrell, J. (2014). *The Effects of Thermal Conditions and Indoor Air Quality on Health, Comfort and Cognitive Performance of Students*. https://www.ucl.ac.uk/bartlett/environmental-design/sites/bartlett/files/migrated-files/cognitiveperformance-1_1.pdf

Ernst, B. (2020). *How to Design Your Office for Improved Productivity and Purpose*. https://blog.bonus.ly/office-design-productivity-and-purpose

Fisk, W.J., Lei, Q., & Seppanen, O. (2006). Effect of temperature on task performance in an office environment. Retrieved from https://indoor.lbl.gov/sites/all/files/lbn1-60946.pdf

Habas, C. (2021). *How the Temperature in the Workplace Impacts Productivity*. https://work.chron.com/temperature-workplace-impacts-productivity-5032.html

Hancock, P. A., Ross, J. M., & Szalma, J. L. (2007). *A Meta-Analysis of Performance Response Under Thermal Stressors*. https://doi.org/10.1518/001872007X230226

Jiang, J., Wang, D., Liu, Y., Di, Y., & Liu, J. (2021). A holistic approach to the evaluation of the indoor temperature based on thermal comfort and learning performance. *Building and Environment*, *196*(19), 107803. https://doi.org/10.1016/j.buildenv.2021.107803

Karjalainen, S. (2011). Thermal comfort and gender: a literature review. Retrieved from doi: 10.1111/j.1600-0668.2011.00747.x

Kohll, A. (2019). *How Your Office Space Impacts Employee Well-Being*. https://www.forbes.com/sites/alankohll/2019/01/24/how-your-office-space-impacts-employee-wellbeing/?sh=63904ef64f31

Kumar, S. (2020). *5 Common Problems Faced By Students In eLearning And How To Overcome Them*. https://elearningindustry.com/5-common-problems-faced-by-students-in-elearning-overcome

Lawless, C. (2018). *What is eLearning?* https://www.learnupon.com/blog/what-is-elearning/

Li, C., & Lalani, F. (2020). *The COVID-19 pandemic has changed education forever. This is how*. https://www.weforum.org/agenda/2020/04/coronavirus-education-global-covid19-online-digital-learning/

Luenendonk, M. (2019). *How Lighting Affects Productivity and Mood*. https://www.cleverism.com/how-lighting-affects-productivity-and-mood/

Nazish, N. (2018). *How To Overcome Mental Fatigue, According To An Expert*. https://www.forbes.com/sites/nomanazish/2018/09/25/how-to-overcome-mental-fatigue-according-to-an-expert/?sh=1c7df0621644

Singh, N. (2018). *Temperature Impacts Workplace Productivity Too*. https://www.entrepreneur.com/article/319479

Smith, A. (2018). *Cognitive Fatigue and the Wellbeing and Academic Attainment of University Students*. https://www.researchgate.net/publication/323121980_Cognitive_Fatigue_and_the_Wellbeing_and_Academic_Attainment_of_University_Students

Tanak, M., Ishii, A., & Watanabe, Y. (2015). Effects of mental fatigue on brain activity and cognitive performance: A magnetoencephalography study. Retrieved from https://www.longdom.org/open-access/effects-of-mental-fatigue-on-brain-activity-and cognitive-performance-amagnetoencephalography-study-2161-0940-S4-002.pdf

Zambito, V. (2020). *Why eLearning Is Even More Valuable Right Now*. https://elearningindustry.com/why-elearning-more-valuable-during-covid-19

Biographies

Matthew P. Solivio was born in 2000 in Laguna, Philippines where he heightened his interest in research and design. In his Senior High School years, he took Practical Research and contributed to the following research paper: (1) Understanding the Lived Experience of Grade 11 Students on Academic Impatience in School Works of University of Perpetual Help System – Binan Campus; (2) The Impacts of Learning Management Systems to the Learning Styles of Grade 11 Students of Mapua University; (3) Reduction of Queuing Time in Land Transportation Office in San Juan District Applying Monte Carlo Simulation and Lean Management. Currently, he is taking his degree in Bachelor of Science in Industrial Engineering at Mapua University.

Deceree Anne A. Haboy was born in 2000 in Cotabato City, Philippines. She graduated Senior High School at Davao Merchant Marine Academy of Sothern Philippines in Davao City. She took the strand Technical-Vocational and Livelihood Major in Welding. In her Senior High School years, she took Practical Research and contributed to the paper entitled "The Effect of the Female Marine Engineers at Work in Cargo Ships". Currently, she is taking a degree in Bachelor of Science in Industrial Engineering at Mapua University.

Kirstien Paola E. Robas was born in 2000 in Metro Manila, Philippines. She is currently a 2nd Year College student in Mapúa University taking a degree in Bachelor of Science in Industrial Engineering. She took up Science, Technology, Engineering, and Mathematics Strand (STEM) in her Senior High School. She has taken part in contributing to the following research papers in Mapúa University Senior High School: (1) Senior High School Strand: How a Parents' Decision and Students' Desire Coincide in Relation to their Motivation in Attending their Classes; (2) Reduction of Queuing Time in Land Transportation Office in San Juan District Applying Monte Carlo Simulation and Lean Management.

Ma. Janice J. Gumasing is a Professor of 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.