Evaluation of Circadian Rhythmic Activity Cycle in line with Academic Activities among Engineering Students Studying in NCR during an Online Setup

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Abstract

The circadian rhythm cycle has a significant impact on students who attend their daily classes at home or online. As students adjust to the new system, sleep deprivation is one of the most significant factors affecting their daily schedules. This study aimed to investigate the impact of the circadian rhythm cycle on engineering students who attend classes at home or online. The researchers used structural equation modeling to analyze relationships between variables such as sleep, grades, workload, and stress levels. The results showed that factors such as academic workload, fatigue, academic stress, screen time, and the number of units had a significant effect on the sleep-wake activity of engineering students. Additionally, academic stress was found to be a contributing factor to psychological well-being, while screen time and hours of sleep were found to be contributing factors to working conditions and individual factors, respectively. To address these issues, the researchers recommend giving students sufficient deadlines for online activities, implementing a system of monitored class length and interval, and providing quick breaks. They also suggest that counseling and medical consultation should be made accessible to students to create a more open environment for discussing mental health and well-being.

Keywords
Circadian Rhythm, Structural Equation Modeling, Sleep-wake, Body Clock, Sleep Disorder

1. Introduction

Ever since the pandemic started everything switched to an online setup, in the course of still adapting to the new setup, sleep is one of the biggest factors that affected the daily cycle of students. A person's sleeping cycle or also known as the circadian rhythm cycle has been a big role in students attending their daily classes off or online. Circadian rhythms are 24-hour cycles that correspond to the body's internal clock. This, in turn, correlates to carrying out essential functions and processes within the body. The most significant example of Circadian rhythm in action is the sleep-wake cycle.

The study aims to aid and provide solutions for the current and future generations to maintain their well-being while having to get high grades. Having to address the cause and effect of the circadian rhythmic activity in line with the academic activities of engineering students would determine concerns of students regarding their sleep that could affect their performance in school.

If the study is successful, better class schedules and workload would be implemented which would benefit both students and professors. This will also avoid sleep disorders such as insomnia, sleep apnea, narcolepsy, restless legs syndrome (RLS), parasomnias, REM sleep behavior disorder, non-24-hour sleep-wake disorder, excessive sleepiness, shift work disorder, and periodic limb movement disorder that hinders the ability of students and professors in doing their work. This study will also be beneficial to the parents because it will save them money for hospitals and will be able to have more family time together. As poor sleep quality was connected to a $3400 to $5200 increase in healthcare spending per person. If a person's sleep quality worsens over a year, healthcare costs will rise. (Grandner, 2018).

1.1 Objectives

The study's goal is to find out which factors, including individual, psychological, environmental, and working conditions, have a significant impact on students. The researchers will compare the factors and analyze their significance. By the end of the study, the researchers will provide information, recommendations, and solutions and raise awareness of engineering students' well-being and academic performance.

With the alarmingly high number of college students suffering from mental health issues and sleep disorders, various problems with daily functioning and nighttime sleep have arisen. The researchers identified various factors that could influence the circadian rhythm of Filipino Engineering students such as individual, psychological, environmental, and working condition factors. The study aims to determine which factors will have a significant effect on students' hours of sleep, sleep-wake activity, homeostatic pressure, cortisol, and melatonin.

H1: Hours of sleep has a significant effect on the sleep-wake activity of Engineering students
H2: Grades has a significant effect on the sleep-wake activity of Engineering students
H3: Duration of studying and review has a significant effect on the sleepwake activity of Engineering students
H4: Duration of classes has a significant effect on the sleep-wake activity of Engineering students
H5: Academic workload has a significant effect on the sleep-wake activity of Engineering students
H6: Fatigue has a significant effect on the sleep-wake activity of Engineering students
H7: Academic-level stress has a significant effect on the sleep-wake activity of Engineering
H8: Excessive nighttime light exposure has a significant effect on the sleepwake activity of Engineering students
H9: Screen time has a significant effect on the sleep-wake activity of Engineering students
H10: School start time has a significant effect on the sleep-wake activity of Engineering students
H11: Number of units has a significant effect on the sleep-wake activity of Engineering students
H12: Hours of sleep has a significant effect on the body temperature of Engineering students
H13: Grades has a significant effect on the body temperature of Engineering students
H14: Duration of studying and reviewing has a significant effect on the body temperature of Engineering students
H15: Duration of classes has a significant effect on the sleep-wake activity of Engineering students
H16: Academic workload has a significant effect on the body temperature of Engineering students
H17: Fatigue has a significant effect on the body temperature of Engineering students
H18: Academic-level stress has a significant effect on the body temperature of Engineering students
H19: Excessive nighttime light exposure has a significant effect on the body temperature of Engineering students
H20: Screen time has a significant effect on the body temperature of Engineering students
H21: School start time has a significant effect on the body temperature of Engineering students
H22: Number of units has a significant effect on the body temperature of Engineering students

These twenty-two (22) hypotheses will determine the relationship between the independent variable and dependent variable.

2. Literature Review

2.1 Circadian Rhythmic Activity Cycle of Adults Ages 18-39 Years Old

The brain is a human's main source of energy and controls the nervous system and with that said sleep is important to regenerate the brain's function. Lack of sleep lowers the ability of the brain to function well. A person's sleep-wake cycle changes as they develop in years and is most likely to lose track of their rhythm. Circadian Rhythm changes due to delays or also called factors affecting the time of sleep, may it be environmental or biological means. According to Healthline "Adults are most likely to be tired from 2 to 4 a.m and 1 to 3 p.m" (Silver, 2020, Circadian Rhythms in Adults). The recommended hours of sleep adults should take is between 7 to 9 hours to fully regain energy and brain and body function

2.2 Sleep Irregularity and Academic Performance

Studies have shown that sleep has been associated with academic performance. Adolescents and young adults who fall asleep later than average and have inconsistent sleep schedules have lower academic performance (Okano et al., 2019). In young adults, a higher mental workload includes the number of hours spent studying, and perceived mental intensity is associated with poorer overall sleep quality (Jansen et al., 2020). However, a study by Gómez-Chiappe et al. (2020) found that students with a GPA less than 4.0 (passing grade of 3.0 out of 5.0) were more associated with poor sleep quality compared with students with a lower GPA.

2.3 School burnout and Sleep quality

In the study of Lehto et al. (2019), they identified that school burnout was related to daytime sleepiness, daytime tiredness, and students' sleep quality. In figure 4, a study by Evers et al. (2020) disturbed sleep due to social media use (DSSM) was defined as reduced or troubled sleep caused by night-time-specific behaviors such as waking to check updates being notified by incoming messages, or postponed bedtime because of social media activities. They found out that adolescents who have experienced school burnout are more likely to, use social media at night. Excessive social media use has the potential to turn vulnerable adolescents into compulsive phone users who have difficulty sleeping. The study's findings reveal a vicious cycle of burnout, sleep disruption, and academic achievement, as well as the impact of academic performance on school burnout.

2.4 Academic-level stress and Sleep quality

The Study by Almojali et al. (2017), highlighted that the high prevalence of stress is one of the most important issues reported among medical students globally. It is defined as the ‘‘wear and tear" the body experiences as it adjusts to pressure or a threatening situation. The current study provided evidence of a high prevalence UNIVERSITY OF SANTO TOMAS 32 of psychological stress (53%) and a high and perhaps even alarming prevalence of poor sleep quality (76%). It reports two important predictor factors of poor sleep quality which are stress and having a low GPA.

2.5 Excessive Nighttime Light Exposure

Sleep disruptions can cause substantial health consequences, including the risk of cancer. Disruption of the circadian rhythm is associated with increased tumor growth and risk of cancer. Circadian rhythm can be disturbed due to exposure to excessive nighttime light pollution and lack of daily sunlight. (Medic et al., 2017).

2.6 Excessive Screen-Time Behaviors and Insufficient Sleep

Over the last decade, a growing number of studies have indicated that using electronic devices like televisions and laptops has a negative impact on sleep quality. According to a study by Baiden et al. (2019), handheld mobile and media gadgets are so prevalent that they are significantly contributing to poor sleep quality. They have also found that excessive screen-time behavior is likely linked to insufficient sleep and that blue light emission from screens has been shown to disrupt the circadian rhythm.

2.7 School Start Time on Adolescent Sleep and Well-Being

Most students wake up before their natural biological wake-up time because their schools start early. One of the most basic strategies for enhancing sleep duration in adolescents is to delay school start hours (Nahmod et al., 2017). In a study by Lo et al. (2018), with a 45-minute delay in school start time, students showed improvements in sleep and well-being after a month, and these favorable effects were maintained after 9 months. Therefore, it is concluded that a students' sleep duration, daytime alertness, and mental well-being can all improve by delaying school start times over time (Lo et al., 2018

2.8 Number of Units or Workload

The study of Tien Ngu et al. (2017) identified a number of factors that influence sleep quality (early classes on weekdays, long lecture hours throughout the day, assessment stress, assignments, and cocurricular activities). In the study the students were asked to rank the criteria from 1 to 5, with 1 being the most important factor affecting sleep quality and 5 being the least important element. As a result of their findings, the majority of the students have identified early courses, long lecture hours, and evaluation stress as the most significant variables affecting their sleep quality. Long daytime lecture hours, which limited their daytime activities while indirectly increasing their nighttime activities resulted in a shorter sleep duration.

3. Methods

The researchers will determine Engineering students studying in NCR by using the method Structural Equation Modeling, circadian rhythm as the dependent variable and academic performance as the independent variable.

Figure 1 which can be seen below is the conceptual framework constructed using the accumulated related literature and studies. Body Temperature and SleepWake Activity are the dependent variables while individual factors, work conditions, psychological factors, and environmental factors affect the dependent variable itself. These, combined with the given solutions or methodology of obtaining data, are preceded and results to the observed and evaluated Circadian Rhythm Cycle of the subject.

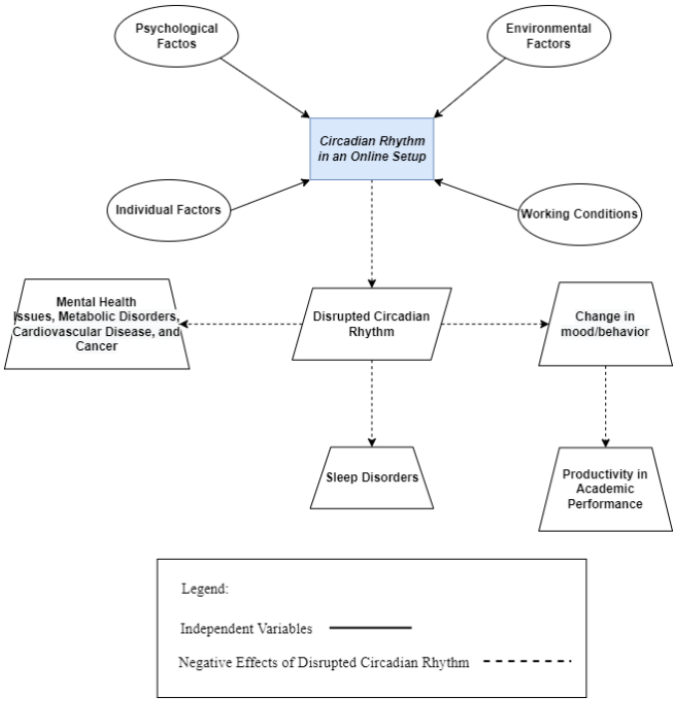

Figure 1. Conceptual Framework

4. Data Collection

Population size is unknown, and the study is a structural equation model, the authors used an online calculator which will automatically calculate the sample size the data for population won't be needed to compute for the sample size since latent and observed variables are the only values needed for the calculation.

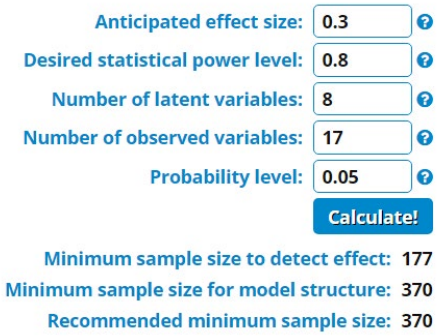

Figure 2. Sample size calculator (Free Statistics Calculator, 2022)

An online free statistics calculator was used to determine the sample size. The figure above (Figure 2) is the appearance of the calculator. The number of latent and observed variables are determined by the number of questions in the survey questionnaire per independent variable. Where latent variables are Fatigue, and Academic-level stress, and based on the questionnaire there are a total of 8 questions. For the observed variables are Screen time, Number of units, School start time, Grades, Duration of classes, Hours of sleep, Duration of studying and review, Excessive Night Light Pollution, Body temperature, and Sleep-wake Activity and based on the questionnaire there a total of 13 questions. And anticipated effect size, desired statistical power level, and probability level are constant.

A survey questionnaire was distributed online through Google Forms from August 2022 to October 2022, and the researchers were able to gather four hundred two (402) responses from all engineering schools in the NCR Region. Table 1 shows the descriptive statistics of the study's respondents.

Table 1. Respondents' Descriptive Statistics (n=402)

Characteristics	Category	N	%
Year	First Year	20	5
	Second Year	33	8.2
	Third Year	110	27.4
	Fourth Year	223	55.5
	Fifth Year	16	4
Gender	Male	189	47
	Female	213	53
School	Ateneo de Manila University	7	1.7
	Adamson University	26	6.5
	Central Colleges of the Philippines	1	0.2
	Centro Escolar University	7	1.7
	Colegio de San Juan de Letran	21	5.2
	De La Salle University	25	6.2
	Don Bosco Technical College	5	1.2
	Far Eastern University Institute of Technology	40	10

	Manuel L. Quezon University	1	0.2
	Mapua University	33	8.2
	New Era University	-	-
	Pamantasan ng Lungsod ng Maynila	13	3.2
	Polytechnic University of the Philippines	17	4.2
	Rizal Technological University	-	-
	San Sebastian College	2	0.5
	STI College	9	2.2
	Technological Institute of the Philippines	27	6.7
	Technological University of the Philippines	8	2.0
	Universidad de Manila	5	1.2
	University of Asia and the Pacific	1	0.2
	University of Makati	3	0.7
	University of Santo Tomas	124	30.8
	University of the East	17	4.2
	University of the Philippines Diliman	10	2.5

5. Results and Discussion

5.1 Numerical Results

In Structural Equation Modeling, the criteria for convergent validity, which require an AVE greater than 0.5, standardized factor loading of all items not less than 0.5 (Cheung & Wang, 2017) while 0.30 to 0.40 are minimal so the researchers will use 0.5 as the significant factor loading value for the study.

Table 2. SPSS Amos Results - Descriptive Statistics and Factor Loading Results

		Item	Mean	Std Dev	Variance	Factor Loading	
						Initial	Final
Psychological	Fatigue	F1	4.455	0.623	0.388	0.489	0.363
		F2	3.582	0.853	0.728	0.389	0.271
	Academic level Stress	S1	4.172	0.665	0.442	0.651	0.539
		S2	3.391	0.770	0.593	0.775	0.865
		S3	4.353	0.582	0.339	0.818	0.757
		S4	3.239	0.930	0.866	0.647	0.715
		S5	4.739	0.523	0.273	0.544	0.373
	Academic Workload	G2	1.060	0.237	0.056	-0.168	-0.108
		G3	1.012	0.111	0.012	-0.138	-0.082
Working Conditions	Screen Time	ST1	3.811	1.134	1.286	0.698	0.773
		ST2	4.410	1.322	1.749	0.783	0.761
		ST3	1.197	0.440	0.193	-0.065	-
	Number of Units	U	23.294	3.293	10.846	-0.482	-0.351
	School Start Time	SST	8.170	1.161	1.347	0.195	-

	Hours of Sleep	HS1 HS2	2.281 3.008	0.482 0.593	0.233 0.352	0.664 0.719	0.620 0.781
	Grades	G1	1.816	0.370	0.137	-0.038	-
Individual	Duration of Classes	D1	29.182	5.215	27.196	-0.432	-0.272
	Duration of Studying and Reviewing	D2	2.040	0.585	0.343	-0.295	-0.257

As seen in Table 2, the initial values for the factor loading are mostly above 0.5 and only values above 0.5 are accepted (Ong et al., 2021). In the final output, ST3, SST, and G1 were removed from the final model as they are not significant or value below 0.5. However, some values are still below 0.5 as this indicates that the AMOS recommended that these factors are still significant.

Therefore, Academic level stress (S1, S2, S3, and S4) is the contributing factor or has a significant effect on psychology. Screen time (ST1 and ST2) is the contributing factor or has a significant effect on working conditions. And hours of sleep (HS1 and HS2) is the contributing factor or has a significant effect on individual factors.

Table 3. SPSS Amos Results of the Hypotheses

Hypotheses	**P-Value**	**Decision**
H1: Hours of sleep has a significant effect on the sleep-wake activity of Engineering students	HS1 = .001 HS2 = .001	Reject H1
H2: Grades has a significant effect on the sleep-wake activity of Engineering students	G1 = -	Reject H2
H3: Duration of studying and review has a significant effect on the sleepwake activity of Engineering students	D1 = 0.001	Reject H3
H4: Duration of classes has a significant effect on the sleep-wake activity of Engineering students	D2 = 0.004	Reject H4
H5: Academic workload has a significant effect on the sleep-wake activity of Engineering students	G2 = 0.011 G3 = 0.002	Accept H5
H6: Fatigue has a significant effect on the sleep-wake activity of Engineering students	F1 = .006 F2 = .005	Accept H6
H7: Academic-level stress has a significant effect on the sleep-wake activity of Engineering	S1 = .005 S2 = .000 S3 = .009 S4 = .003 S5 = .005	Accept H7
H8: Excessive nighttime light exposure has a significant effect on the sleepwake activity of Engineering students	-	Reject H8

H9: Screen time has a significant effect on the sleep-wake activity of Engineering students	ST1 = .009 ST2 = .000 ST3 = -	Accept H9
H10: School start time has a significant effect on the sleep-wake activity of Engineering students	SST = -	Reject H10
H11: Number of units has a significant effect on the sleep-wake activity of Engineering students	U = .001	Accept H11
H12: Hours of sleep has a significant effect on the body temperature of Engineering students	HS1 = .001 HS2 = .001	Accept H12
H13: Grades has a significant effect on the body temperature of Engineering students	G1 = -	Reject H13
H14: Duration of studying and reviewing has a significant effect on the body temperature of Engineering students	D1 = 0.001	Accept H14
H15: Duration of classes has a significant effect on the sleep-wake activity of Engineering students	D2 = 0.004	Accept H15
H16: Academic workload has a significant effect on the body temperature of Engineering students	G2 = 0.011 G3 = 0.002	Accept H16
H17: Fatigue has a significant effect on the body temperature of Engineering students	F1 = .006 F2 = .005	Accept H17
H18: Academic-level stress has a significant effect on the body temperature of Engineering students	S1 = .005 S2 = .000 S3 = .009 S4 = .003 S5 = .005	Accept H18
H19: Excessive nighttime light exposure has a significant effect on the body temperature of Engineering students	-	Reject H19
H20: Screen time has a significant effect on the body temperature of Engineering students	ST1 = .009 ST2 = .000 ST3 = -	Reject H20
H21: School start time has a significant effect on the body temperature of Engineering students	SST = -	Reject H21
H22: Number of units has a significant effect on the body temperature of Engineering students	U = .001	Reject H22

Table 3 above depicts the statistical results of the 22 (twenty-two) hypotheses by using SPSS Amos Standardized Direct Effects – Two-Tailed Significance. Wherein, 11 hypotheses are accepted and P-values less than 0.05 are to be accepted. (Jayawardana & Weerasinghe, 2019)

Table 4. Model Fit Indices

Goodness of Fit Measures	Parameter Estimates	Minimum Cutoff	Suggested by
Incremental Fit Index (IFI)	0.850	>0.80	Ong, et al., 2021
Tucker Lewis Index (TLI)	0.802	>0.80	Ong, et al., 2021
Comparative Fit Index (CFI)	0.848	>0.80	Ong, et al., 2021
Goodness of Fit Index (GFI)	0.891	>0.80	Ong, et al., 2021
Adjusted Goodness of Fit Index (AGFI)	0.842	>0.80	Ong, et al., 2021
Root Mean Square Error of Approximation (RMSEA)	0.083	<0.07	Ong, et al., 2021

Referring to Table 4 above, the researchers modified the indices to improve the model fit as the results of the model fit fell short of the suggested cut-off value. After the necessary changes were done, the values of the Incremental Fit Index (0.850), Tucker Lewis Index (0.802), Comparative Fit Index (0.848), Goodness of Index (0.891), and Adjusted Goodness of Fit Index (0.842) are all above the suggested cut-off of 0.70 considered to be an absolute fit (Ong et al.,2021). The Root Mean Square Error (0.083) value is greater than the specified minimum threshold. RMSEA values below 0.10 indicate a marginal fit (Dagnall et al., 2018).

Table 5. Composite Reliability

Factor		Constructs	Cronbach's Alpha	AVE	Composite Reliability
Psychological	Fatigue	F1 F2	0.624	0.476	0.645
	Academic-level Stress	S1 S2 S3 S4 S5	0.801	0.470	0.816
	Grades	G2 G3	0.510	0.445	0.616
Working Conditions	Screen Time	ST1 ST2 ST3	0.511	0.170	0.381
Individual	Hours of Sleep	HS1 HS2	0.656	0.499	0.665

In assessing the reliability of the survey results, the researcher utilizes Cronbach's alpha as it is a measure of internal consistency among variables — that is, how closely a group of items are related to one another. Defining Table 5 above, according to Taherdoost et al. (2017), in the pilot study phase the reliability result should be equal to

or above 0.60. The study of Mat Nawi et al. (2020) also suggested four cut-off points for reliability, which include excellent reliability (0.90 and above), high reliability (0.70-0.90), moderate reliability (0.50-0.70) and low reliability (0.50 and below). Based on the results, factors such as Academic-level Stress (0.816) with high reliability, Fatigue (0.645), Grades (0.616), and Hours of Sleep (0.665) showing moderate reliability, and Screen Time (0.381) showing low reliability.

5.2 Proposed Improvements

Amongst the other Predictive Models, **Individual Factors such as Hours of Sleep and Duration of Classes has a direct effect on Temperature** is recognized as one of the most significant and most occurring factors. According to CSUN (n.d.) and referring to Table 6, it is recommended that the implementation of observed duration and interval of classes and short breaks be administered by faculty and staff.

Table 6. Recommended Breaks in Classes (CSUN, n.d.)

Lecture Class/Duration Time	Recommendation
9:39 AM - 10:45 AM (One hour & fifteen minutes)	No break should be necessary
8:00 A.M – 9:45 P.M.. (Two hours & 45 minutes)	One break of 10-15 minutes
9:00 A.M. – 2:30 P.M.	Two or more breaks of 10-15 minutes each

Working Conditions such as Screen Time and Number of Units has a direct effect on the Sleep-Wake Cycle is also deemed significant amongst the factors. It is recommended by the proponents that to prevent the extraneous amount of Exposure to Blue Light or the Screen Monitor, students should utilize other modes of learning within their limited four corners; This is through implementing activities that utilize and maximize traditional and tangible pedagogies. This is through the implementation of handwritten activities, physical research and at-home lab activities, and more so. Aside from the application of a different pedagogy, the academia of the aforementioned colleges should utilize a limited timeframe and adequate deadline towards the implementation of online activities amongst students, wherein the time utilized would give an adequate means of both sleep duration and undermining activities for students. The researchers would recommend an amount of workload amounting to **five (5) per week** and **one (1) quiz** or **assessment** per day (within normal school days, not accounting for special or days designated for examinations.)

The Predictive Models within Psychological Factors such as Fatigue, Academic-level Stress, and Academic Workload has a direct effect on Sleep-Wake Cycle. In order to aid with such, the researchers would propose an evaluation amongst the faculty and the students' psyché, observations, and rating towards their respective subjects, amount of workload, internal and external stressors, and many more. This can be implemented via the utilization of the platform *Google Forms.* Furthermore, the results should be reflected within the given workload and other factors, in correlation to the responses of the students themselves. A thorough selection and observation of the amount of workload should be given and implemented;

Lastly, **Psychological Factors have a direct effect on Temperature.** Researchers propose to recommend amongst the faculty that counseling and medical consultation would be accessible amongst students. This, in turn, would create a more open environment in concerns related to both mental health and well-being, all the while a better, more open, communicative approach between students and faculty. It is recommended that a form or shortcut tab for more accessibility in the Consultation forms for medical consultations be present within the university's local sites and moreso. Furthermore, medical accessibility is a priority, both mental and physical health, hence an accessible server or site is also recommended.

5.3 Validation

Getting data or information from the participants may be difficult as other participants are unwilling to disclose details about their sleep cycle. Another problem is participants not answering the given survey questions honestly which can

result in inaccurate data analysis. With the said problem the researchers made sure that all of the data collected will be anonymous so the responses will not be able to identify the identity of the respondent. The researchers will not discuss or disclose any information to other people and will use data gathered for academic purposes only. This study will also be complex with the reason that the researchers have limited knowledge when it comes to some medical terms and backgrounds which will be used for the research. Another reason is the researchers consider multiple variables to assess a person's rhythm to create solutions for them. The data of the study were collected only once but it should have been collected daily and then taken its average to help minimize bias and increase the accuracy and reliability of the results. The percentage given in the questionnaire is also only assumed by the respondents so it does not apply to every grading system.

6. Conclusion

Academic activities can impact the circadian rhythm cycle of engineering students studying in NCR, according to the accepted assumptions (H5, H6, H7, H9, H11, H12, H14, H15, H16, H17 and H18). Even yet, there are still gaps in the study that prevent the researchers from conclusively stating whether or not the circadian rhythm is disturbed. As there isn't enough data to fully establish the circadian rhythm, the researchers then offered several recommendations for future research to improve the study.

Additionally, this research will assist students in improving their body clocks and sleep-wake cycles so they can enhance their well-being without compromising the subjects' academic performance. Faculty members and/or professors in schools who are responsible for implementing the curriculum will also become more informed as a result of this study, enabling them to give their students an appropriate workload and class schedule.

References

Almojali, A., et al., The prevalence and association of stress with sleep quality among medical students, *Journal of Epidemiology and Global Health*, vol. 7, no. 3, pp. 169– 174, 2017.

Baiden, P., et al., The association between excessive screen-time behaviors and insufficient sleep among adolescents: Findings from the 2017 Youth Risk Behavior Surveillance System, Psychiatry Research, Available: https://doi.org/10.1016/j.psychres.2019.112586, 2019.

Cheung, G. W. and Wang, C. Current approaches for assessing convergent and discriminant validity with SEM: Issues and solutions, *Academy of Management Proceedings*, vol. 1, p. 12706, 2017.

Evers, K., et al., Investigating the relation among disturbed sleep due to social media use, school burnout, and academic performance, *Journal of Adolescence*, vol. 84, pp. 156–164, 2022.

Gómez-Chiappe, N., et al., Poor sleep quality and associated factors in university students in Bogotá D.C., Colombia, *Sleep Science*, vol. 13, no. 2, pp. 125-130, 2020.

Dagnall, N., et al., Confirmatory Factor Analysis of the Inventory of Personality Organization-Reality Testing Subscale, Available: https://doi.org/10.3389/fpsyg.2018.01116, 2018.

Grandner, M., The Cost of Sleep Lost: Implications for Health, Performance, and the Bottom Line, *The American Journal of Health Promotion*, vol. 32, no. 7, pp. 1629-1634, 2018.

Jansen, E., et al., Associations between Mental Workload and Sleep Quality in a Sample of Young Adults Recruited from a US College Town, *Behavioral Sleep Medicine*, vol. 18, no. 4, pp. 513–522, 2019.

Jayawardana, A and Weerasinghe, T., Flex-Work and Work-Life Balance: Effects of Role Culture, *Research Gate,* vol. 24, pp. 46-76

Lo, J. C., et al., Sustained benefits of delaying school start time on adolescent sleep and well-being, Available: https://doi.org/10.1093/sleep/zsy052, June 2018.

Mat Nawi, F., et al., A review on the internal consistency of a scale: The empirical example of the influence of human capital investment on Malcom Baldridge Quality Principles in TVET institutions, *Asian People Journal (APJ)*, vol. 3, no. 1, pp. 19-29, 2020.

Medic G, et al., Short- and long-term health consequences of sleep disruption, *Nature and Science of Sleep*, vol. 2017, no. 9, pp. 151-161, 2017.

Okano, K., et al., Sleep quality, duration, and consistency are associated with better academic performance in college students, Available: https://www.nature.com/articles/s41539-019-0055-z, October 1, 2019.

Ong, K., et al., Consumer Behavior in Clothing Industry and Its Relationship with Open Innovation Dynamics during the COVID-19 Pandemic, Available: https://doi.org/10.3390/joitmc7040211, October 8, 2021.

Silver, N., Everything to Know About Your Circadian Rhythm, Available: https://www.healthline.com/health/healthysleep/circadian-rhythm, March 30, 2022.
Soper, D., Free Statistics Calculator, Available: https://www.danielsoper.com/statcalc/calculator.aspx?id=89, November 2022.
Taherdoost H., Determining Sample Size; How to Calculate Survey Sample Size. *International Journal of Economics and Management Systems,* vol. 2, 2017.
Tien Ngu, S., et al., Sleep Quality among Pre-Clinical Medical Students in Universiti Putra Malaysia and Universiti Malaya, Malaysia, *Education in Medicine Journal*, vol. 9, no. 3, pp. 23–31, 2017.

Biographies

Assoc. Prof. Carlos Ignacio P. Lugay Jr., Ph.D., PIE, ASEAN Eng is a graduate of Bachelor of Science in Industrial Engineering at the University of Santo Tomas. He took his Masters in the said course in the University of the Philippines-Diliman and his PhD in Commerce in University of Santo Tomas. He is also a Former Department Chair in the University of Santo Tomas Department of Industrial Engineering and was a Faculty Secretary of the Faculty of Engineering.

Rich Anne D. Dela Cruz was born in Bulacan, Philippines in 2001. She is currently a fourth-year Industrial Engineering student at the University of Santo Tomas. She has participated in student organizations at her current university to enhance and develop soft skills, such as the UST Industrial Engineering Circle and UST Operations Research Society of the Philippines. She also had her internship in McDonald's Philippines under the Strategy and Insights Data and Analytics Department to continue enhancing her hard skills and gaining knowledge and experience that is relevant to her course and interests.

Erika Anne C. Maaño was born in Quezon City, Philippines in 2000. She is a fourth-year Industrial Engineering student at the University of Santo Tomas. She enhanced her soft and technical skills by joining the organization Industrial Engineering Circle in the position of Associate Executive for Publicity from 2020 until 2022. And back in 2020, together with her groupmates, they coined the 2nd Place in their 10th SIPOC Week Exhibit.

Vhyns Erlic V. Mahaguay was born in Makati, Philippines, in 2000. He is currently a fourth-year industrial engineering student at the University of Santo Tomas. He developed an interest in engineering in childhood because his father is also an engineer; hence, he took the Science, Technology, Engineering, and Mathematics (STEM) strand during senior high school at Mapua University. He had his internship as an industrial engineer at ECC International, which is the leading process improvement solutions provider in Southeast Asia.

Jan W. Sta Ana was born in Balanga, Bataan in 2001. Currently situated in Taguig, Metro Manila, she is currently a fourth-year Industrial Engineering student at the University of Santo Tomas. In order to garner and quip more knowledge and skills via experience, she has joined numerous organizations. She is a current member of the UST Industrial Engineering Circle and has been a member for 3 consecutive years. She also poses as a talent for Tiger Media Network, and has hosted and starred onto multiple shows broadcasted by the network. She also had her internship for *Robert Bosch Incorporated* under the Supply Chain and Management Department, which aligns not only of her course, but mainly her interest within the Industrial Engineering field.