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Mental Workload Analysis of Industrial Engineering Students in Cebu Technological University: National Aeronautics and Space Administration-Task Load Index

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A B S T R A C T:

The NASA-Task Load Index provides a framework for assessing mental workload. Mental workload is one of the factors that influence students' performance in the academe. This study was a descriptive quantitative analysis conducted on Bachelor of Science in Industrial Engineering students of Cebu Technological University (CTU) - Danao Campus. The NASA-Task Load Index (NASA-TLX) method was employed to measure students' mental workload. The study revealed that the Industrial Engineering students of CTU-Danao experienced a significant mental workload. Gender differences were also observed, specifically, the majority of the female students predominantly perceived their mental workload as low while the male had a high level of mental workload. The average mental workload score for both genders is at a moderate level.

Keywords: sources of load, magnitude of load, task load index, load dimensions

1. INTRODUCTION:

The Bachelor of Science in Industrial Engineering (BSIE) program follows a structured curriculum, spanning 201 units across 8 semesters. In the year 2021, there was a change of curriculum for the BSIE program, from 164 total units to 201 total units. The purpose of this study was to evaluate the mental burden experienced by the first batch of industrial engineering students who are navigating the transition to the new curriculum. By understanding their level of mental workload, the institution can make informed decisions to support student well-being and enhance the learning experience. Thus, as students embrace this curriculum transformation, it becomes imperative to assess the extent of the mental workload experienced by industrial engineering students as their academic burden increases. To achieve this, the study employs the NASA Task Load Index (NASA-TLX) method to evaluate the mental workload experienced by industrial engineering students. Through this assessment, the researchers seek to inform educational policies and enhance the overall learning experience within the program.

Human performance is significantly influenced by mental workload. The NASA Task Load Index (NASA-TLX) serves as a widely adopted method for evaluating mental workload. This method involves subjective ratings across six dimensions, which are then combined into a single workload score using various techniques (Bolton et al., 2023). These dimensions—such as Mental Demand, Physical Demand, and Frustration—are essential for understanding the subjective workload experienced during different tasks (Vinoth et al., 2020). Workload emerges from task demands, environmental factors, behavioral competencies, and worker quality. It encompasses both physical and mental aspects (Umam et al., 2022). The NASA Task Load Index (NASA-TLX) has been modified to better reflect mental workload by adjusting items like Emotional Demand and Performance Monitoring Demand (Al Madi et al., 2022). These dimensions offer a comprehensive evaluation of the workload experienced during a task. Mental demand refers to the cognitive aspects of the task, while physical demand relates to the physical exertion required. Temporal demand involves time pressure, frustration indicates the level of annoyance or dissatisfaction, effort signifies the amount of effort invested, and performance assesses the perceived effectiveness in completing the task.

Furthermore, studies have shown that perceived workload in programming projects, as measured by NASA-TLX, can impact students' self-efficacy and disproportionately affect underrepresented students (Bolton et al., 2023). Research also reveals that perceptions of workload, stress, fatigue, and academic performance vary throughout the semester, with notable gender differences (Grepo, 2023). Addressing skill gaps, particularly non-technical skills, is vital for student success and retention in engineering programs, especially among underrepresented groups (Hernandez et al., 2018). Numerous studies underscore the substantial pressure and workload faced by engineering students, significantly impacting their academic performance and overall well-being. These stressors arise from external demands, self-imposed expectations, and rigorous academic requirements (Grepo, 2023). Specifically, research within the field of industrial engineering—both at the undergraduate and postgraduate levels—highlights workload intensity as a prevalent issue. Factors

such as inadequate support, self-imposed performance pressure, and the fear of missing deadlines contribute to students' perceived workload burden. Moreover, individual perceptions of workload are influenced by class contact hours, independent study commitments, and learning approaches. Curriculum designers must carefully consider these factors to prevent students from feeling overwhelmed by their academic responsibilities (Smith, 2019).

Student workload encompasses hours spent attending lectures, seminars, and tutorials, and engaging in independent study, project preparation, and exams. Each semester, courses carry specific credit values, reflecting the student's study load. While credit systems vary, workload estimates remain approximate. Notably, long study hours are not excessive if courses are well-designed (Ernawati, Pujiyanto, & Suhardi, 2019). Research on engineering students' mental workload due to educational demands reveals significant effects. Pre-professional practices and academic activities contribute to increased mental load, impacting performance (Septiawati et al., 2022). Assessments using tools like NASA-TLX highlight the link between workload and performance, emphasizing the need for balanced cognitive abilities (Corrales et al., 2020).

1.1 Sources of Load (Weights)

The NASA Task Load Index (TLX) utilizes a multidimensional approach to assess mental workload by deriving an overall workload score based on weighted averages of six subscales: mental demand, physical demand, temporal demand, performance, effort, and frustration level. These subscales represent different sources of workload experienced by operators during task performance, with three subscales focusing on the demands imposed by the task (mental, physical, and temporal demand) and the other three subscales emphasizing the interaction of the operator with the task (performance, effort, and frustration level (Lowndes et al., 2020). The weights or loads assigned to each of these subscales are crucial in computing the overall workload score, with the NASA TLX providing a structured framework for integrating these various load sources to obtain a comprehensive assessment of mental workload in different work environments (Afridi et al., 2020).

1.2 Magnitude of Load (Ratings)

The second requirement is to obtain numerical ratings for each scale that reflect the magnitude of that factor in a given task. The NASA Task Load Index (NASA-TLX) is utilized to measure the magnitude of loads in various settings. Studies have shown that the NASA-TLX method is effective in assessing workload in different environments, such as e-learning scenarios, intensive care units (ICUs) for nurses, and surgical procedures for surgeons (Febiyani et al., 2021). The overall workload score for each subject is computed by multiplying each rating by the weight given to that factor by that subject.

2. OBJECTIVES OF THE STUDY

- To assess the extent of the mental workload of the Industrial Engineering students at Cebu Technological University – Danao Campus

3. REVIEW OF LITERATURE:

Jääskeläinen 2022: Study found that class schedules, teaching methods, and peer interactions significantly influence student workload. Poorly organized schedules can lead to time conflicts, causing students to feel overwhelmed, whereas flexible schedules help manage time and workload more effectively. Innovative and engaging teaching methods enhance learning experiences and reduce perceived workload, especially when they cater to diverse learning styles. Peer interactions also play a crucial role, as collaborative efforts and supportive peer relationships can help distribute workload, share resources, and create an environment where students manage their responsibilities more efficiently.

Didin 2021: measured workers' mental and physical workload while working from home and found that the mental workload values for males and females were not significantly different, but females had an average mental workload 9.98 units higher than males. Both males and females showed a high level of physical workload, with more than 60% categorized as heavy work based on their calorie needs. The study revealed that males had a reasonably high workload, with 98 in the high workload category, while females had 40 in the medium workload category and 60 in the high workload category.

4. RESEARCH METHOD:

4.1 Research design

This research study was based on a descriptive qualitative analysis to assess the Mental Workload of 3rd-year Industrial Engineering Students at CTU-Danao using the NASA-TLX method. Data were gathered through data and document reviews to ensure accuracy and reliability.

4.2 Population of the Study

This study focuses on undergraduate students enrolled in the Bachelor of Science in Industrial Engineering (BSIE) program at Cebu Technological University—Danao Campus, specifically the industrial engineering students belonging to the Class of 2025. The table below summarizes data based on the gender and block sections of the students.

Table 1 - Summary of the Population of the Study

Block Section	Category	Number of Students
A – DAY	Female	22
	Male	14
B – DAY	Female	22
	Male	12
A – NIGHT	Female	20
	Male	11
B – NIGHT	Female	23
	Male	8

The industrial engineering students were chosen because they are the first batch to experience the new curriculum for the undergraduate program. Instead of the previous 164 units, they now need to complete 201 units. This curriculum change may impact their workload and academic experiences. The total number of students is 132.

4.3 Interpretation of Score Value Results

The NASA Task Load Index (NASA-TLX) provides a valuable tool for assessing mental workload in various settings, including educational environments. The score values obtained from NASA-TLX can be interpreted as follows: very low indicates minimal mental workload, low signifies a slight increase in workload, moderate suggests a reasonable level of mental demands, high denotes a significant workload, and very high represents an excessive and overwhelming mental burden. These categories help in understanding the intensity of mental effort required by students, which can impact their academic performance and overall well-being (Ernawati, suhardi & pujiyanto 2019).

Table 2 – Scoring Procedure

Interpretation	Value
Very Low	0-20
Low	21-40
Moderate	41-60
High	61-80
Very High	81-100

4.4 Data Collection Tool

This study's primary data collection tool was the NASA Task Load Index (NASA-TLX) questionnaire developed by Hart and Staveland in 1988. The NASA-TLX is a well-established subjective workload assessment tool widely used in various research fields (Hart, 2019; Grier, 2022). The NASA-TLX Questionnaires consisted of six measurement dimensions, namely the mental, physical, and temporal demand, performance, effort, and frustration. Each dimension was assessed using a scale to measure the perceived workload of the students. Post-collection results were evaluated using the NASA-TLX method, a well-established subjective workload assessment tool introduced by Hart and Staveland. Mohammdi et al. (2019) confirmed the questionnaire's reliability and validity with a Cronbach's alpha of 0.89. Cronbach's alpha is a statistical measure used to assess the internal consistency or reliability of a set of survey items or test questions. An alpha of 0.89 implies that the items in your survey or assessment instrument are internally consistent and measure the intended characteristic effectively.

5. RESULTS AND DISCUSSION:

The total number of industrial engineering students at CTU-Danao Campus is 132, and an equivalent number of documents were assessed and analyzed for data collection. The NASA-TLX included six (6) dimensions, which included a two-part evaluation procedure consisting of both weights (sources of loads) and ratings (magnitude of loads). The following is an analysis of the collected data:

Table 3 - Mental workload scores of all Industrial Engineering Students.

Total Students	Average Workload Score (Global Index)	Interpretation
5	74.5	Very low
39	133.5	Low
28	198.2	Moderate
45	279	High
14	349.3	Very high

Table 2 depicts the mental workload (global index) scores of all industrial engineering students. Five students have a very low global index with an average workload score of 74.5 in all industrial engineering students. Thirty-nine students have a low global index with an average workload score of 133.5 and twenty-eight students have a moderate global index with an average workload score of 198.2. Forty-five students which is the highest among the other number of students have a high global index with an average workload score of 279. Fourteen students have a very high global index of 349.3 average workload score. According to Pratama et al. (2022), using the NASA-TLX method conducted on students revealed that a significant number of students experience high mental workloads during their learning process. Both studies reveal that students also experience a significant mental workload.

Table 4 - Mental workload scores Based on Gender.

Gender	Total Students	Average Workload Score (Global Index)	Interpretation
Female	2	9.5	Very low
	29	33.5	Low
	21	49.5	Moderate
	27	68.8	High
	8	88.2	Very high
Overall score (Female)	**87**	**49.9**	**Moderate**
Male	3	9.1	Very low
	10	31.4	Low
	7	38.6	Moderate
	19	71.3	High
	6	63	Very high
Overall score (Male)	**45**	**42.68**	**Moderate**

Table 4 above presents the average workload score (Global Index) of industrial engineering students based on gender. Among females, two students have a very low global index with an average workload score of 9.5, 29 students have a low global index with an average score of 33.5, 21 students have a moderate global index with an average score of 49.5, 27 students have a high global index with an average score of 68.8, and eight students have a very high global index with an average score of 88.2. Among males, three students have a very low global index with an average score of 9.1, ten students have a low global index with an average score of 31.4, seven students have a moderate global index with an average score of 38.6, 19 students have a high global index with an average score of 71.3, and six students have a very high global index with an average score of 63. Based on the research findings of the study of Patel (2022), there is no significant difference in mental workload between male and female students. Patel's study and the current study's results collectively suggest that gender does not play a significant role in determining mental workload levels among students. Additionally, it also highlights the importance of focusing on other factors that may contribute to mental workload rather than gender-centric strategies.

Table 5 – Variance Analysis of the Mental workload scores of Students based on Gender.

Source of Variation	Degree of Freedom	Sum of Squares	Mean Squares	F-Value	
				Computed F	Tabular
Treatment (Bet. Columns)	33	16426.590	497.775	1.399	.284
Expt'l Error (Within Columns)	11	3913.219	355.747		

= not significant

Table 5 indicates that there is no significant difference in the mental workload scores between male and female Industrial Engineering students which was calculated using IBM-SPSS software. The null hypothesis, which states that there is no significant difference between the mental workload scores of male and female students, fails to be rejected. The analysis resulted in an F-value of 1.399 with degrees of freedom [F(33,11)], and a p-value of 0.284, which is greater than the significance level of 0.05. Consequently, the p-value suggests that gender does not significantly impact the perceived mental demands of the students. According to the study of Panda & Azeem (2022) which studied male and female college students and also reported no significant difference in mental health dimensions between genders. Therefore, based on Panda and Azeem (2022) and the current studies, it can be concluded that there is no significant difference in mental workload or mental health status between male and female students in various academic settings and that there is not enough evidence to conclude that gender significantly impacts the perceived mental demands of the students.

4. Conclusion

There was no significant difference in the mental workload of the male and female BSIE students of Cebu Technological University – Danao Campus. Thus, the mental workload does not matter according to sex. This suggests that the new curriculum affects both sexes similarly which also highlights the importance of considering workload management strategies that apply universally, regardless of sex. However, for the female BSIE students, the majority of them had a low mental workload while the male had a majority of a high level of mental workload. This implies that most female students are more effective in managing their mental workload while most male students are less effective in managing their mental workload. However, on average, both male and female had a moderate rate of mental workload. These findings underscore the necessity for the institution to address these workload factors to manage and reduce mental workload, ensuring a balanced and supportive academic environment for all students at Cebu Technological University - Danao.

Bibliography:

1. Afridi, A. H., & Mengash, H. A. (2020). NASA-TLX-based workload assessment for academic resource recommender system. Personal and Ubiquitous Computing, 1-19. https://doi.org/10.1007/s00779-020-01409-z
2. Al Madi, N., Peng, S., & Rogers, T. (2022). Assessing workload perception in introductory computer science projects using NASA-TLX. In SIGCSE 2022: Proceedings of the 53rd ACM Technical Symposium on Computer Science Education - Volume 1 (pp. 668–674). https://doi.org/10.1145/3478431.3499406
3. Bolton, M. L., Biltekoff, E., & Humphrey, L. (2023). The mathematical meaninglessness of the NASA Task Load Index: A level of measurement analysis. IEEE Transactions on Human-Machine Systems, 53(3), 590-599. https://doi.org/10.1109/THMS.2023.3263482
4. Corrales, C., Rojas, J., & Atoche, W. (2020). Impact of pre-professional practices on the excessive mental workload of university engineering students. In W. Karwowski, R. Goonetilleke, S. Xiong, R. Goossens, & A. Murata (Eds.), Advances in physical, social & occupational ergonomics. AHFE 2020. Advances in intelligent systems and computing (Vol. 1215). Springer, Cham. https://doi.org/10.1007/978-3-030-51549-2_57
5. Didin, F. S., Maharani, B. P., & Mardiono, I. (2021). Work from home study: Mental workload, gender, and calorie needs. Jurnal Sistem dan Manajemen Industri (Universitas Serang Raya), 5(1), 1-7. https://doi.org/10.30656/JSMI.V5I1.2768

6. Ernawati, R., Suhardi, B., & Pujiyanto, E. (2019, April). Using the NASA task load index and heart rate to evaluate vocational student's mental and physical workload. In AIP Conference Proceedings (Vol. 2097, No. 1). AIP Publishing.
7. Ernawati, R., Suhardi, B., & Pujiyanto, E. (2019). Using the NASA Task Load Index and heart rate to evaluate vocational students' mental and physical workload. AIP Conference Proceedings, 2097, 030057. https://doi.org/10.1063/1.5098259
8. Febiyani, A., Febriani, A., & Ma'sum, J. (2021). Calculation of mental load from e-learning student with NASA TLX and SOFI method. Jurnal Sistem dan Manajemen Industri, 5(1), 35-42. https://doi.org/10.30656/jsmi.v5i1.2789
9. Grier, R. A. (2022). How high is high? A meta-analysis of NASA-TLX global workload scores. Ergonomics, 59(10), 1401-1416.
10. Grepo, L. (2023). Students' perceived workload, stress, fatigue and performance during the remote learning setup: A semester-long study. In S. Nazir (Ed.), Training, education, and learning sciences. AHFE (2023) International Conference (Vol. 109). AHFE Open Access. AHFE International, USA. https://doi.org/10.54941/ahfe1003161
11. Hart, S. G., & Staveland, L. E. (1988). Development of NASA-TLX (Task Load Index): Results of empirical and theoretical research. In P. A. Hancock & N. Meshkati (Eds.), Human mental workload (pp. 139–183). North-Holland
12. Hart, S. G. (2019). Nasa-task load index (NASA-TLX); 20 years later. In Proceedings of the human factors and ergonomics society annual meeting (Vol. 50, No. 9, pp. 904-908). Sage CA: Los Angeles, CA: SAGE Publications
13. Hernandez, N. V., Fuentes, A., & Crown, S. (2018). Effectively transforming students through first year engineering student experiences. In 2018 IEEE Frontiers in Education Conference (FIE) (pp. 1-5). IEEE. https://doi.org/10.1109/FIE.2018.8658752
14. Jääskeläinen, T., López-Íñiguez, G., & Phillips, M. (2022). Music students' experienced workload in higher education: A systematic review and recommendations for good practice. Musicae Scientiae, 102986492210939-102986492210939. https://doi.org/10.1177/10298649221093976
15. Lowndes, B. R., Forsyth, K. L., Blocker, R. C., Dean, P. G., Truty, M. J., Heller, S. F., Blackmon, S. H., Hallbeck, M. S., & Nelson, H. (2020). NASA-TLX assessment of surgeon workload variation across specialties. Annals of Surgery, 271(4), 686-692. https://doi.org/10.1097/SLA.0000000000003058
16. Mohammadi, A., Esmaeili, M., & Ghapanchi, A. H. (2019). Evaluation of the NASA-TLX-Based Software Usability Evaluation Method: A User-Centered Approach. International Journal of Human-Computer Interaction, 35(10), 854-865.
17. Panda, Y., & Azeem, K. (2022). Comparative study of mental health among male and female college students. Revista Romaneasca pentru Educatie Multidimensionala, 14(4), 121-130. https://doi.org/10.18662/rrem/14.4/632
18. Patel, M. (2022). Gender differences in mental health of international graduate students. International Journal of Multidisciplinary Research and Analysis, 5(6). https://doi.org/10.47191/ijmra/v5-i6-11
19. Pratama, A. Y., Yamani, A. Z., Marier, S. M., Nurchasanah, N., & Safa'at, M. A. (2022). Experimental ergonomic approach in analysis of student mental workload in using learning management system. Jurnal Ilmiah Teknik Industri, 21(2), 125-134. https://doi.org/10.23917/jiti.v21i2.19742
20. Septiawati, V., Hidayat, N. P. A., & Septiani, A. (2022). Evaluation of ergonomics and mental workload: A case study in education personnel. KnE Social Sciences, 7(17), 112–120. https://doi.org/10.18502/kss.v0i0.12313
21. Smith, A. P. (2019). Student workload, wellbeing and academic attainment. In L. Longo & M. Leva (Eds.), Human mental workload: Models and applications. H-WORKLOAD 2019. Communications in computer and information science (Vol. 1107). Springer, Cham. https://doi.org/10.1007/978-3-030-32423-0_3
22. Umam, m., Harpito, H., Lestari, F., Rizki, M., Nazaruddin, N., anwardi, A., Nofirza, N., & Karmala Sari, . (2022). Workload Analysis using NASA-TLX and SWAT METHODS in Shop Floor Company X. In 3rd Asia Pacific International Conference on Industrial Engineering and Operations Management, https://doi.org/10.46254/AP03.20220788.
23. Vinoth, P., Pandian, S., & Suleri, S. (2020). NASA-TLX Web App: An online tool to analyze subjective workload. arXiv: Human-Computer Interaction.