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Case study article

Analysis of mental workload during exams in hybrid learning in the new normal era post-pandemic

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ABSTRACT

During the Covid-19 pandemic, most universities implemented distance learning to prevent the spread of the virus. After the pandemic, the learning process shifted to a hybrid method, combining both offline and online instruction. This hybrid system is applied to certain courses, featuring face-to-face classroom sessions alongside video conferencing for lectures. However, the hybrid learning approach has led to a decline in the student achievement index for some students, highlighting the need to evaluate their mental workload. Therefore, this study aimed to measure students' mental workload during both online and offline exams using the NASA Task Load Index (NASA-TLX) method. The results showed a higher average mental workload score for offline exams compared to online exams. Statistical analysis revealed a significant difference between the scores, indicating a notable disparity in mental workload between offline and online exams. In conclusion, the mental workload associated with hybrid learning—particularly during exams—is considered high.

1. Introduction

During the Covid-19 pandemic, the Indonesian Government decided to cancel face-to-face teaching and learning activities in schools and universities, replacing them with distance learning to prevent the spread of the virus. The importance of online and distance learning activities has increased in schools and universities throughout Indonesia since the Covid-19 pandemic, even though the number of universities using distance learning systems in all courses was almost non-existent before the pandemic [1].

Distance learning activities have several advantages and disadvantages. The advantages of distance learning, especially for e-learning, are that distance learning activities are very flexible in terms of time and place. The disadvantages of distance learning include students not learning effectively when using computers, they do not like [2], and they may experience discomfort such as eye disease, hand and wrist pain, waist, back, neck, and head injuries when studying in front of a computer screen for a long time [3].

In the distance learning process, student performance is influenced by psychosocial factors in addition to anthropometric and environmental factors [4]. Meanwhile, factors that influence online learning fatigue include the number of hours of sleep that are below normal sleep hours, fasting activities, and work activities [5]. In addition, the level of stress during learning is caused by the quantity of assignments that are considered excessive, demands for fast submission times and limited understanding of the material obtained by students.

After the Covid-19 pandemic ended, the learning process at several universities adopted a hybrid learning method, which is a combination of offline and online learning. The hybrid learning system is applied to some courses, with face-to-face classroom sessions, lectures via video conference, and use of Online

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platforms [6]. During the Covid-19 pandemic, exams were carried out online; after the pandemic, they shifted to a combination of online and offline methods. The implementation of online exams often utilizes teleconference media and internet-based platforms. These changes in learning and teaching patterns for students, from offline to online and then to hybrid, can cause mental workload [7], alongside pressures from assignments and short deadlines [8].

The existence of this hybrid learning exam system has led to several complaints from students, for example, students in Industrial Engineering programs at some universities have reported difficulty managing exam time, focusing on the subject matter, and adapting to the examination process itself. Studies conducted during the fully online learning period indicated that a significant portion of students experienced moderate mental workload classification (63.21%) and heavy workload classification (22.97%) [9]. Furthermore, the highest dimensions of workload felt by students were related to time requirements and mental requirements [10]. Therefore, it is necessary to measure the mental workload in the hybrid learning process to determine the level of mental workload of students.

This study aims to analyze and compare the mental workload experienced by students during online and offline exams within a hybrid learning framework. The National Aeronautics and Space Administration Task Load Index (NASA-TLX), a widely used and validated subjective workload assessment tool, was employed. The NASA-TLX was selected for its ability to provide a multidimensional measure of workload, encompassing mental demand, physical demand, temporal demand, performance, effort, and frustration level, making it well-suited to capture the complex cognitive and stress-related experiences of students across diverse examination settings.

The findings are expected to offer valuable insights into educational institutions on how different exam modalities impact students' mental well-being. This understanding can guide the development of more supportive and effective examination strategies in the post-pandemic era, ultimately enhancing the learning experience and potentially improving academic outcomes.

2. Literature review

Mental workload is a crucial aspect that affects student performance and well-being in the academic context, especially considering changes to learning models. The sudden transition to remote learning during the COVID-19 pandemic, followed by the shift to hybrid learning models, has presented unique challenges related to students' mental workload [7, 8]. These changes in teaching and learning patterns, including adjustments in exam implementation, have the potential to increase students' mental workload [7]. Previous research conducted during the period of full online learning, such as that reported by Umyati et al. [9], indicated that most students experienced moderate to high levels of mental workload. Furthermore, the dimensions most frequently perceived as burdensome by students were related to time demands and mental demands [10].

In the context of evaluating this workload, the National Aeronautics and Space Administration Task Load Index (NASA-TLX) is a well-established and widely used research method to calculate multidimensional mental workload scores. NASA-TLX is chosen for its ability to assess workload based on six dimensions: mental demand, physical demand, temporal demand, own performance, effort, and stress level or frustration [12, 13]. The development of NASA-TLX by Hart and Staveland [13] as well as Hancock and Meshkati [14] provides a comprehensive framework for this subjective measurement. The indicators for assessing mental workload using NASA-TLX can be found in Table 1 [14]. Following the presentation of the mental workload indicators table, a weighting and assessment process is conducted. In the weighting process, subjects may indicate which factors or descriptions contribute the most (and least) to the workload they experienced while working. Subjective evaluations of the contribution of different workload sources can vary across different tasks, reflecting both objective experimental manipulations (mental, physical, and time requirements) and individual responses to the task [15].

Table 1
NASA-TLX dimensions.

Dimensions	Rating	Description
Mental Demand (MD)	Low, High	How much mental and perceptual activity was required (e.g., thinking, deciding, calculating, remembering, looking, searching, etr.)? Was the task easy or demanding, simple or complex, exacting or forgiving?
Physical Demand (PD)	Low, High	How much physical activity was required (e.g. pushing, pulling, turning, controlling, activating. etc.)? Was the task easy or demanding. slow or brisk. slack or strenuous, restful or laborious?
Temporal Demand (TD)	Low, High	How much time pressure did you feel due to the rate or pace at which the tasks or task elements occurred? Was the pace slow and leisurely or rapid and frantic?
Effort (EF)	Low, High	How hard did you have to work (mentally and physically) to accomplish your level of performance?
Performance (OP)	Good, Poor	How successful do you think you were in accomplishing the goals of the task set by the experimenter (or yourself)? How satisfied were you with your performance in accomplishing these goals?
Frustation Level (FR)	Low, High	How insecure, discouraged, irritated, stressed and annoyed versus secure, gratified, content, relaxed and complacent did you feel during the task?

Table 2
NASA-TLX classification.

No	Workload group	Value
1	Low	0-9
2	Medium	10-29
3	Rather High	30-49
4	High	50-79
5	Very High	80-100

Mental workload assessment using NASA-TLX is then classified into several categories, as shown in the classification in Table 2. The final score classification of mental workload measured using the NASA-TLX method is divided into five categories: low, moderate, somewhat high, high, and very high.

Although research has explored workload in general online learning contexts [9, 10] and the application of NASA-TLX is well-documented [12, 13, 14], there remains a need to specifically understand how mental workload differs between online and offline exam formats within the hybrid learning systems that are now commonly implemented post-pandemic. This study aims to fill that gap by applying the NASA-TLX framework to compare these exam modalities, taking into account how students' subjective experiences [15] contribute to the overall workload score.

3. Material and method

This study employed a quantitative approach with a cross-sectional study design, where primary and secondary data were collected at a specific point in time to analyze students' mental workload during exams in a post-pandemic hybrid learning system.

3.1. Participants and sampling

Primary data collection was conducted by distributing the NASA-TLX questionnaire to students of the Industrial Engineering Department at Universitas Sultan Ageng Tirtayasa (Untirta). A total of 95 students participated in this study, comprising three academic cohorts: 18 students from the 2020 cohort (18.95%), 35 students from the 2021 cohort (36.84%), and 42 students from the 2022 cohort (44.21%). This participant selection aimed to obtain an overview of workload from students with varying levels of academic experience in facing the hybrid examination system.

3.2. Research instruments and data collection

The main instrument used was the NASA-TLX questionnaire, which consists of two main parts:

(1) Weighting: Fifteen pairwise comparison questions were posed to determine the relative weight of the six NASA-TLX workload dimensions for each respondent. Respondents chose the dimension that most influenced their workload for each pair.
(2) Rating: Six rating questions were administered for each of the NASA-TLX dimensions: Mental Demand, Physical Demand, Temporal Demand, Own Performance, Effort, and Frustration Level. Respondents provided a score on a 0-100 scale for each dimension based on their experience during online and offline exams.

Secondary data included literature studies related to mental workload and NASA-TLX, data on courses examined in the Industrial Engineering Department, the number of credits taken, as well as data on the number of Industrial Engineering students at Untirta from the 2020-2022 cohorts and course data in semester 2, semester 4, and semester 6. Data collection was carried out after respondents completed the final exams for the even semester in specific courses conducted both online and offline.

3.3. Research variables

The dependent variable in this study was the students' mental workload score. The main independent variable was the mode of exam implementation (online vs. offline). Respondents' demographic characteristics (gender, cohort) and course types were also collected as descriptive data.

3.4. Research procedure

The stages of this research included several main steps as follows:

(1) Preparation: Including literature review, development of the NASA-TLX questionnaire, and identification of courses and participants.
(2) Data Collection: Distribution of the questionnaire to respondents after the implementation of online and offline exams.
(3) NASA-TLX Data Processing
    - Weighting NASA-TLX Scores: Calculating the weights for each of the six dimensions based on responses to the pairwise comparison questions.
    - Rating NASA-TLX Scores: Recording the raw scores (0-100) provided by respondents for each dimension.
(4) Calculating NASA-TLX Mental Workload Scores: Multiplying the rating scores by their corresponding weights for each dimension, then summing them to obtain the total Weighted Workload (WWL) score for each respondent for both online and offline exams.
(5) Classification of NASA-TLX Mental Workload Scores: Categorizing the obtained WWL scores into five workload levels (low, medium, rather high, high, very high) based on predetermined score ranges (referring to Table 2).
(6) Comparative Analysis: Comparing the results of

mental workload scores between online and offline exam implementations. Relevant statistical tests (such as the paired *t*-test) will be used to determine if there is a statistically significant difference between the two conditions.

4. Results and discussions

4.1. Results

This sub-section presents the findings from the data collected, covering respondent demographics, mental workload scores from the NASA-TLX analysis for both offline and online exams, and a statistical comparison between the two exam modalities.

4.1.1. Respondent demographics and course characteristics

A total of 95 Industrial Engineering students participated in this study. As detailed in Table 3, respondents comprised 50 males (52.63%) and 45 females (47.37%). The distribution across academic cohorts was: 42 students from the class of 2022 (44.21%), 35 from the class of 2021 (36.84%), and 18 from the class of 2020 (18.95%).

Table 3
Respondent characteristics.

No	Variable	Description	Total	Percentage
1	Gender	Male	50	52.63
		Female	45	47.37
2	Grade	2022	42	44.21
		2021	35	36.84
		2020	18	18.95

Table 4
Offline and online courses.

No	Learning	Course	Total	Percentage
1	Online	Basic Physics 2	42	44.21
		Ergonomics 2	1	1.05
		Macro Ergonomics	8	8.42
		Data Analytics	37	38.95
		Marketing Management	7	7.37
2	Offline	Industrial Ecology	42	44.21
		Ergonomics 2	35	36.84
		Engineering Economics	17	17.89
		Data Analytics	1	1.05

Table 5
Total variables and average scores of mental workloads for online and offline lectures.

Category	Offline score		Online score	
	Total	Average	Total	Average
MD	17945	188.89	15541	163.59
PD	6823	71.82	6151	64.75
TD	15935	167.74	16981	178.75
OP	19108	201.14	19875	209.21
EF	19752	207.92	15144	159.41
FR	16288	171.45	14348	151.03

Table 4 outlines the distribution of courses for which the workload was assessed. For online exams, the courses included Basic Physics 2 (44.21%), Data Analytics (38.95%), Engineering Economics (not explicitly listed but implied by overall offline distribution), Macro Ergonomics (8.42%), Marketing Management (7.37%), and Ergonomics 2 (1.05%). For offline exams, the distribution included Industrial Ecology (44.21%), Ergonomics 2 (36.84%), Engineering Economics (17.89%), and Data Analytics (1.05%).

4.1.2. Mental workload scores

The NASA-TLX method was used to assess mental workload across six dimensions for both offline and online exams. Table 5 summarizes the total and average scores for each dimension. For the offline exam, the average scores for the dimensions were as follows: Mental Demand (MD) – 188.89, Physical Demand (PD) – 71.82, Temporal Demand (TD) – 167.74, Own Performance (OP) – 201.14, Effort (EF) – 207.92, and Frustration (FR) – 171.45. The overall average mental workload score for offline exams was 67.26, placing it in the high workload category. The Effort dimension (207.92) was the most influential contributor to workload in offline exams.

For the online exam, the average scores for the dimensions were: MD – 163.59, PD – 64.75, TD – 178.75, OP – 209.21, EF – 159.41, and FR – 151.03. The overall average mental workload score for online exams was 61.78, also categorized as high workload. The Own Performance dimension (209.21) was the most influential for online exams, followed closely by Temporal Demand (178.75).

4.1.3. Comparison of offline and online exam workload

A paired t-test was conducted to determine if there was a significant difference in mental workload scores between offline and online exams. The analysis yielded a significance value of 0.009, which is less than the α level of 0.05 ($p < 0.05$). This indicates a statistically significant difference in perceived mental workload between the two exam modalities, with offline exams eliciting a higher mean workload. The average workload scores for offline to online exams was approximately 1.08:1.

4.1.4. Distribution of workload categories

Workload scores showed that 4 individuals (4.21%) were in the moderate category, 14 (14.74%) in the rather high category, 68 (71.58%) in the high category, and 9 (9.47%) in the very high category. This underscores that most students experienced high to very high mental workload during exams in the hybrid learning environment.

4.2. Discussions

This section interprets the findings presented above,

discusses them in the context of existing literature, outlines the implications, and acknowledges the study's limitations.

4.2.1. *Summary and interpretation of key findings*

The study revealed that students experienced a high level of mental workload during both offline (mean score 67.26) and online (mean score 61.78) examinations in a hybrid learning environment. Notably, offline exams were perceived as significantly more demanding than online exams. The 'Effort' dimension was paramount for offline exams, while 'Own Performance' and 'Temporal Demand' were key for online exams. These findings highlight the substantial cognitive and psychological demands placed on students adapting to varied assessment methods post-pandemic.

4.2.2. *Factors influencing offline exam workload*

The high mental workload score during offline exams, particularly driven by the 'Effort' dimension, can be attributed to several factors. The traditional format, involving written responses within a fixed time limit and direct supervision in a physical classroom, likely contributes to this [16, 17]. The physical act of writing, coupled with the pressure of time and invigilation, demands considerable mental and physical effort and concentration. This aligns with previous research suggesting that the perceived intensity of direct supervision can heighten stress and perceived effort during assessments [21].

4.2.3. *Factors influencing online exam workload*

Although lower than offline exams, online exams still registered a high workload. This was primarily influenced by the 'Own Performance' and 'Temporal Demand' dimensions. Factors contributing to online exam workload often include unstable internet connections, potential difficulties in understanding questions without face-to-face interaction, and environmental distractions at home. The high 'Temporal Demand' score suggests students felt significant time pressure, a common issue in online assessments [10]. The prominence of 'Own Performance' might indicate that while students felt the pressure, they also had a strong focus on achieving their desired outcomes, or perhaps the perceived control over their environment (despite distractions) influenced their self-assessment of performance. However, technical difficulties, as frequently cited in literature, can significantly impact performance and increase frustration, even if not the highest-rated dimension here [22].

4.2.4. *Comparison with previous research*

The finding that both exam modalities impose a high mental workload is consistent with numerous studies conducted during and after the COVID-19 pandemic. For instance, Fenyvian et al. [19] reported a high average workload (72.00) in a different context, suggesting that demanding tasks generally elicit high workload responses. Our overall workload scores are also comparable to studies specifically focusing on students in hybrid or online learning environments. For example, reference [23] found similarly high NASA-TLX scores among university students in a hybrid system, also noting 'Temporal Demand' as a significant stressor.

The significantly higher workload for offline exams found in this study aligns with some research suggesting that traditional, time-bound, supervised written exams can induce greater immediate stress and perceived effort compared to some online formats, especially if the online formats offer more flexibility or perceived anonymity [24]. However, this is not universal, as other studies, such as [25], have indicated that poorly designed online exams or intrusive online proctoring can lead to higher mental workload than well-structured offline exams. The specifics of the online exam administration in our study (e.g., level of proctoring) might influence this outcome.

The difference in dominant NASA-TLX dimensions (Effort for offline, Own Performance/Temporal Demand for online) provides nuanced insights. The high 'Effort' offline is well-supported by literature emphasizing the physical and mental exertion of traditional exams [16, 17]. The high 'Own Performance' rating in online exams, despite the overall high workload, could reflect students' adaptation, higher self-efficacy in familiar digital environments, or even a different perception of success criteria when not under direct supervision [26].

The overarching context of a hybrid learning system, which inherently divides student focus between online and offline learning modes [20], likely contributes to a baseline level of heightened cognitive load. Reference [27] also discussed how frequent modality switching in hybrid education can increase cognitive demands, potentially making exam preparation itself more taxing. This is further supported by research during the emergency remote teaching phase of the pandemic, where high stress and workload were consistently reported [28], and our findings suggest these elevated levels may persist if hybrid models are not carefully managed. Technical infrastructure remains a critical concern for online assessments [29], and while not the primary driver in our study, it is an underlying factor that can exacerbate workload. The need for students to develop robust coping strategies and time management skills in these new academic landscapes is also paramount [30].

4.2.5. *Implications of the findings*

The results of this study have several important implications for educational institutions and instructors.

First, exam design must be approached carefully to minimize excessive mental workload in both online and

offline settings. For offline exams, this may involve ensuring sufficient time allocation and providing clear, unambiguous instructions. Meanwhile, online exams require attention to platform stability, effective communication channels, and reasonable time limits to reduce unnecessary cognitive strain.

Second, there is a need for enhanced student support mechanisms to help students cope with exam-related stress and workload, particularly in hybrid learning environments. Institutions could offer workshops on time management, stress reduction strategies, and academic counseling services.

Third, instructors should be aware of the varying degrees of mental workload that different exam formats can impose. This awareness should inform assessment planning and encourage the adoption of more student-centered approaches. Lastly, the prominent role of the 'Own Performance' dimension in online exams highlights the need for further investigation to better understand students' self-perceptions and performance-related expectations in virtual testing environments.

5. Conclusions

This study aimed to measure and compare students' mental workload during online and offline exams within the hybrid learning system implemented post-pandemic at the Industrial Engineering Department, Universitas Sultan Ageng Tirtayasa, using the NASA-Task Load Index (NASA-TLX) method.

The findings revealed that students experienced a high level of mental workload during both examination modalities. The average mental workload score for offline exams was 67.26, while for online exams it was 61.78. Both scores fall into the "high" workload category according to NASA-TLX classifications. A statistically significant difference was found between the two, indicating that offline exams were perceived as inducing a significantly higher mental workload than online exams. For offline exams, the 'Effort' dimension was the primary contributor to workload, whereas for online exams, 'Own Performance' and 'Temporal Demand' were the most influential dimensions.

The higher workload in offline exams is likely attributed to factors such as the pressure of direct supervision, fixed time limits for written responses, and the physical and mental exertion required. Conversely, while lower, the high workload in online exams can be associated with time pressures, concerns about self-performance, potential technical issues, and environmental distractions.

These results underscore the considerable cognitive and psychological demands placed on students navigating hybrid learning and assessment environments. Educational institutions should, therefore, consider these findings when designing examination strategies. This includes optimizing the structure of both online and offline exams to mitigate excessive workload, providing adequate student support services to manage exam-related stress, and ensuring instructors are aware of the workload implications of different assessment formats.

Limitations of this study include its focus on a specific department at one university and reliance on self-reported data. Future research could expand to diverse student populations, incorporate longitudinal designs to track workload over time, and use mixed methods approaches to gain deeper qualitative insights into students' experiences with exam workload in hybrid settings. Ultimately, understanding and addressing student mental workload is crucial for fostering a more supportive and effective learning environment in the new normal era.

Declaration statement

Ani Umyati: **Conceptualization, Methodology, Supervision, Project administration**. Ade Sri Mariawati: **Software**. Lovely Lady: **Resources, Validation**. Nustin Merdiana Dewantari: **Resources, Visualization, Investigation**. Lely Herlina: **Data curation, Validation**. Yayan Harry Yadi: **Supervision, Validation, Editor**. Rezi Alvizar: **Writing - Original Draft.**

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Data availability statement

The authors confirm that the data supporting the findings of this study are available within the article or its supplementary materials.

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The authors confirm that no generative AI or AI-assisted tools were used in the creation or writing of this manuscript. All content has been entirely produced, reviewed, and edited by the authors without the assistance of AI technologies.

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