

Cognitive Fatigue Among Santri in Dual-Curriculum Islamic Boarding Schools

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Abstract

Keywords:

Cognitive fatigue; dual curriculum; Islamic boarding school; Qur'anic memorization; adolescent mental health.

Cognitive fatigue has emerged as a critical concern in educational settings that require sustained mental effort, particularly in Islamic boarding schools implementing dual-curriculum systems. Santri are required to balance intensive Qur'anic memorization with formal general education, creating substantial cognitive demands that may affect learning effectiveness and mental well-being. This study aims to examine the level of cognitive fatigue among santri and to identify key contributing factors within a dual-curriculum pesantren context. A quantitative descriptive design was employed involving 120 students aged 13–18 at Darul Iman Islamic Boarding School, North Lombok, Indonesia. Data were collected using the Pediatric Cognitive Fatigue Scale (PCFS), supported by classroom observations and analysis of study duration, sleep patterns, and memorization load. The findings indicate that most students experience moderate to high levels of cognitive fatigue. Fatigue levels were strongly associated with prolonged daily study time exceeding ten hours, reduced sleep duration, and high Qur'anic memorization intensity, while gender and age were not significant predictors. These results highlight the cumulative cognitive risks of extended academic engagement without adequate rest. This study contributes to the limited empirical literature on student cognitive fatigue in religious education environments. The findings imply the need for pesantren administrators and policymakers to redesign learning schedules by incorporating structured rest periods, balanced memorization targets, and sleep protection strategies to promote healthier and more sustainable learning environments for adolescents in dual-curriculum Islamic boarding schools.

Abstrak

Kata kunci:
Kelelahan kognitif;
kurikulum ganda;
pesantren; hafalan
Al-Qur'an; kesehatan
mental remaja.

Kelelahan kognitif telah muncul sebagai masalah kritis dalam lingkungan pendidikan yang membutuhkan upaya mental berkelanjutan, khususnya di pesantren yang menerapkan sistem kurikulum ganda. Santri dituntut untuk menyeimbangkan hafalan Al-Qur'an yang intensif dengan pendidikan umum formal, sehingga menciptakan tuntutan kognitif yang substansial yang dapat memengaruhi efektivitas pembelajaran dan kesejahteraan mental. Studi ini bertujuan untuk meneliti tingkat kelelahan kognitif di kalangan santri dan mengidentifikasi faktor-faktor kunci yang berkontribusi dalam konteks pesantren kurikulum ganda. Desain deskriptif kuantitatif digunakan yang melibatkan 120 siswa berusia 13–18 tahun di Pesantren Darul Iman, Lombok Utara, Indonesia. Data dikumpulkan menggunakan Skala Kelelahan Kognitif Pediatrik (PCFS), didukung oleh observasi kelas dan analisis durasi belajar, pola tidur, dan beban hafalan. Temuan menunjukkan bahwa sebagian besar siswa mengalami tingkat kelelahan kognitif sedang hingga tinggi. Tingkat kelelahan sangat terkait dengan waktu belajar harian yang lebih lama dari sepuluh jam, durasi tidur yang berkurang, dan intensitas hafalan Al-Qur'an yang tinggi, sedangkan jenis kelamin dan usia bukan merupakan prediktor yang signifikan. Hasil ini menyoroti risiko kumulatif dari keterlibatan akademis yang berkepanjangan tanpa istirahat yang cukup. Studi ini berkontribusi pada literatur empiris yang terbatas tentang kelelahan kognitif siswa di lingkungan pendidikan

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agama. Temuan ini menyiratkan perlunya administrator pesantren dan pembuat kebijakan untuk mendesain ulang jadwal pembelajaran dengan memasukkan periode istirahat terstruktur, target hafalan yang seimbang, dan strategi perlindungan tidur untuk mempromosikan lingkungan belajar yang lebih sehat dan berkelanjutan bagi remaja di pesantren yang menggunakan kurikulum ganda.

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INTRODUCTION

Cognitive fatigue is increasingly recognized as a critical factor influencing students' academic performance and mental health, especially in settings requiring sustained cognitive effort (Kunasegaran et al., 2023; McMorris et al., 2018; Milyavskaya et al., 2021; Smith, 2018). Defined as a decline in mental efficiency following prolonged cognitive engagement, cognitive fatigue can lead to decreased attention, impaired memory, and reduced motivation (Behrens et al., 2023a; Dehais et al., 2020; Martin et al., 2018). While numerous studies have examined cognitive fatigue in general educational contexts, little attention has been given to religious educational institutions, where students often engage in demanding dual-curriculum systems. The unique cognitive demands faced by students in Islamic boarding schools (pesantren) in Indonesia, who balance intensive Qur'anic memorization with formal academic subjects, warrant focused investigation. In Indonesia, pesantren serve as prominent centers for Islamic education, combining traditional religious instruction with secular curricula mandated by the national education system (Arif et al., 2020; Harto et al., 2025; Rahmawati & Dwijayanti, 2024). This dual-curriculum approach, while enriching in scope, imposes substantial cognitive loads on students (santri), requiring them to allocate time and mental resources between memorization of the Qur'an and learning subjects such as mathematics, science, and language (Nurfaisal et al., 2024). Recent studies have highlighted that santri face elevated risks of cognitive overload, which can manifest as fatigue, stress, and reduced academic efficacy (Ansori et al., 2025). This scenario presents a critical challenge in optimizing educational practices without compromising student well-being.

Empirical evidence suggests that cognitive fatigue is influenced by several factors including study duration, intensity of memorization, sleep quality, and rest breaks (Benkirane et al., 2022; Gilsoul et al., 2022; Kayser et al., 2022; Simon et al., 2020). In dual-curriculum settings, prolonged study hours combined with insufficient rest can exacerbate fatigue, potentially affecting cognitive functions such as working memory and executive control (Anto, 2025; Levingston, 2023). For instance, a recent study by (Muttaqin et al., 2024) in Indonesian Islamic schools revealed that santri engaged in more than 10 hours of daily combined study reported significantly higher levels of mental fatigue, correlating with diminished attention and slower information processing. Despite these findings, few studies have explicitly addressed cognitive fatigue within the context of Qur'anic memorization alongside general education. Beyond the academic workload, psychosocial factors also play a pivotal role in influencing cognitive fatigue among santri. Boarding school environments can induce emotional stress due to

separation from family, peer dynamics, and the pressure to meet religious and academic expectations (Ahmed et al., 2023; Ramadani et al., 2025). These stressors, coupled with cognitive demands, create a compounded effect on students' mental resources (Wang et al., 2024). Moreover, gender and age differences may moderate the experience of cognitive fatigue, although current evidence is inconclusive (Fadhilah, 2022). A comprehensive understanding of these multifaceted contributors is essential to design effective interventions that promote cognitive resilience and sustainable learning in pesantren.

The objective of this study is to examine the level and determinants of cognitive fatigue among santri enrolled in dual-curriculum Islamic boarding schools. Specifically, the study aims to analyze the relationship between daily study duration and cognitive fatigue, assess the moderating role of sleep duration, and evaluate the contribution of Qur'anic memorization intensity to fatigue levels. In addition, this research seeks to validate the impact of cognitive fatigue on objective cognitive performance through a working memory task and to identify the potential buffering role of extracurricular activities as a cognitive recovery mechanism. By doing so, the study intends to provide empirical evidence to inform culturally sensitive curriculum management strategies that balance academic, religious, and cognitive well-being demands in pesantren education.

Despite the growing body of research on cognitive fatigue in general educational contexts, empirical studies examining this phenomenon within religious educational institutions particularly Islamic boarding schools with dual-curriculum demands remain scarce. Most existing studies emphasize academic outcomes or spiritual achievement without adequately addressing cognitive well-being as a structural component of curriculum design. This gap limits a comprehensive understanding of how prolonged study schedules, intensive memorization practices, and restricted rest periods interact to shape students' cognitive health. Therefore, this research is necessary to provide empirical evidence on cognitive fatigue among santri and to reposition mental health considerations as a critical variable in pesantren curriculum planning. By addressing this gap, the study offers a novel contribution to the literature and informs evidence-based strategies for optimizing learning schedules, integrating restorative practices, and supporting the holistic development of santri in navigating the dual demands of religious commitment and formal education.

METHOD

This study employed a quantitative descriptive design to measure cognitive fatigue among santri enrolled in a dual-curriculum Islamic boarding school system (Bloomfield & Fisher, 2019). Quantitative descriptive research is appropriate for systematically collecting and analyzing numerical data to describe characteristics of a population or phenomenon (Creswell et al., 2007; Creswell & Hirose, 2019). The research was conducted at Darul Iman Islamic Boarding School, North Lombok, Indonesia, where students undertake both Qur'anic memorization and formal academic learning. A purposive sampling technique was utilized to select 120 students aged between 13 and

18 years who met inclusion criteria of active enrolment in both curricula and consent to participate.

Data collection involved standardized instruments to assess cognitive fatigue, supplemented by structured questionnaires to capture demographic and academic workload information. The Paediatric Cognitive Fatigue Scale (PCFS), validated for adolescent populations, was used to quantify subjective cognitive fatigue levels. This self-report instrument assesses mental exhaustion, reduced motivation, and concentration difficulties on a Likert scale, offering reliable and valid measurement in educational research contexts (Riccardi & Ciccia, 2021). Additionally, study hours, sleep duration, and extracurricular activities were documented through daily logs maintained by participants and cross-verified with teacher reports to ensure data accuracy.

Data analysis employed descriptive statistics and inferential tests to identify patterns and correlations between cognitive fatigue and potential predictors such as study load and sleep quality. The use of Pearson’s correlation and multiple regression analysis enabled the exploration of relationships between variables, consistent with best practices in educational research methodology (Stapor, 2020). Ethical approval was obtained from the institutional review board, ensuring participant confidentiality and voluntary participation. The methodological approach allowed for a comprehensive assessment of cognitive fatigue within the complex dual-curriculum context of Indonesian Islamic boarding schools.

RESEARCH RESULTS AND DISCUSSION

Result

This study involved 120 students (santri) from Darul Iman Islamic Boarding School, located in North Lombok. Participants were composed of 62 males (51.7%) and 58 females (48.3%), with an age range of 13 to 18 years and a mean age of 13.1 years (SD = 1.8). The students followed a dual curriculum: Islamic studies with Qur’an memorization and general academic subjects. On average, students reported studying for 10.2 hours daily (SD = 2.3) and sleeping for approximately 6.9 hours per night (SD = 1.2). The Pediatric Cognitive Fatigue Scale (PCFS), used to assess mental fatigue, produced an overall mean score of 50.6 (SD = 11.5), indicating a moderate level of cognitive fatigue across the population. These findings support previous research suggesting that intensive, prolonged academic demands can have measurable cognitive impacts (Kubicek et al., 2023).

To better understand the distribution of fatigue, students were categorized into four groups based on their total study duration per day: less than 8 hours, 8 to 10 hours, 10 to 12 hours, and more than 12 hours (see table 1 bellow).

Table 1.

Cognitive Fatigue and Sleep by Study-Hour Category

Study Hours/Day	Sample Size (N)	Mean PCFS Score	Standard Deviation (PCFS)	Average Sleep Hours/Night
< 8 hours	25	38.5	7.2	8.1

8-10 hours	45	46.2	8.1	7.4
10-12 hours	30	54.7	9.4	6.5
> 12 hours	20	62.1	10.3	5.8

Corresponding mean PCFS scores were 38.5, 46.2, 54.7, and 62.1 respectively. The steady increase in fatigue levels with additional study time suggests a dose-response relationship. One-way ANOVA revealed significant between-group differences ($F(3,116) = 16.03, p < 0.001$). Post hoc Tukey tests confirmed that each step in study duration resulted in statistically significant increases in fatigue, as shown in the following boxplot

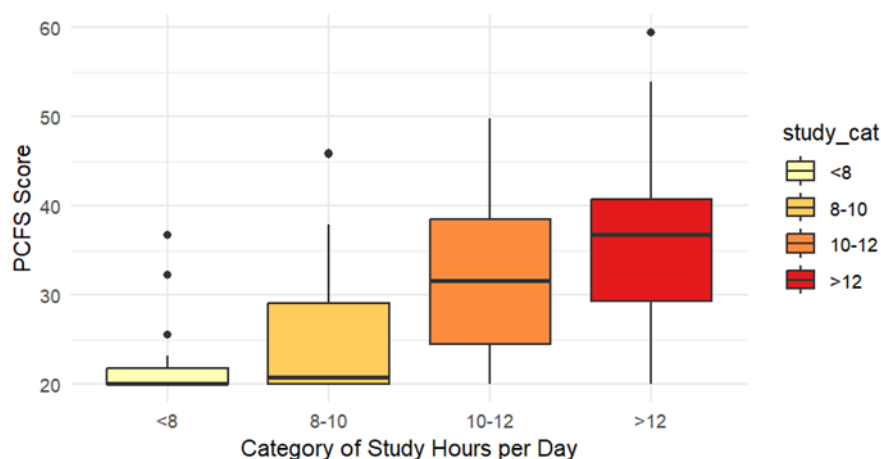


Figure 1. Cognitive Fatigue Based on Study Hour Category

This evidence underscores the cumulative cognitive strain from long hours of uninterrupted academic engagement and affirms literature findings on workload-related fatigue escalation (Altman et al., 2021).

Table 2. One-Way ANOVA Summary for PCFS Scores by Study Duration

Source	Sum of Squares (SS)	df	Mean Square	F	Sig.
Between Groups	2886	3	961.9	16.03	< .001
Within Groups	6960	116	60.0		
Total	9846	119			

Sleep duration was significantly and negatively correlated with PCFS scores ($r = -0.57, p < 0.001$). This means that students who slept fewer hours reported notably higher levels of cognitive fatigue, as shown in the following figure 2.

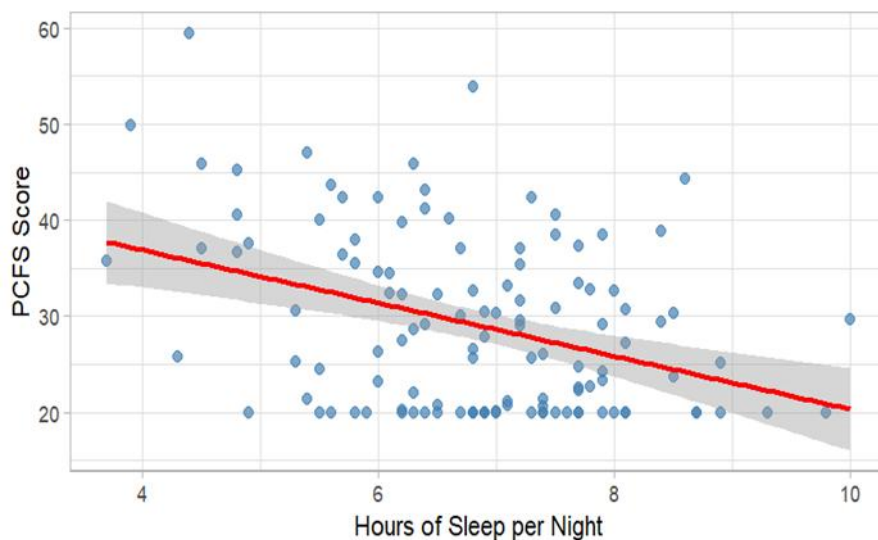


Figure 2. The Relationship Between Sleep Hours and Cognitive Fatigue

Furthermore, hierarchical linear regression showed that study hours alone accounted for 39% of the variance in fatigue ($R^2 = 0.39$), and when sleep duration was added, the explained variance increased to 53% ($\Delta R^2 = 0.14$, $p < 0.001$). Specifically, each lost hour of nightly sleep was associated with a 4.9-point increase in PCFS scores.

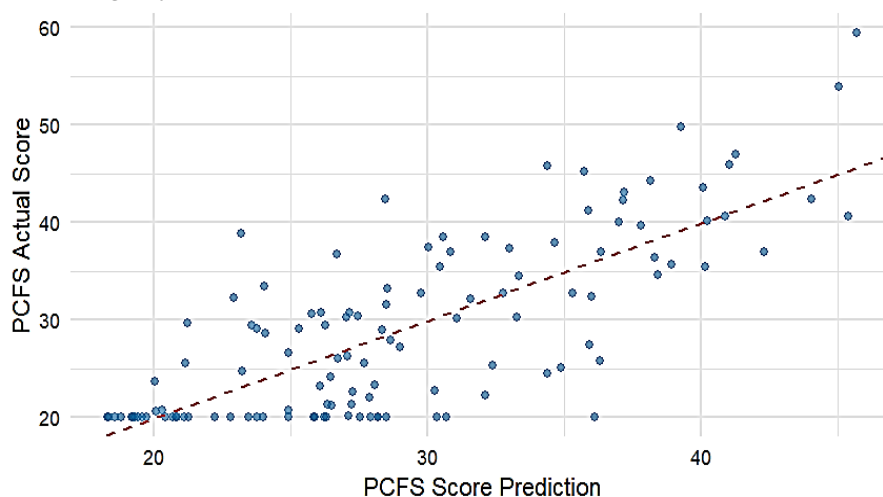


Figure 3. Predicted vs Actual PCFS Score Values

These results are aligned with studies such as that of (Garcia et al., 2021), which demonstrated the critical role of adequate sleep-in regulating attention and executive functioning in adolescents.

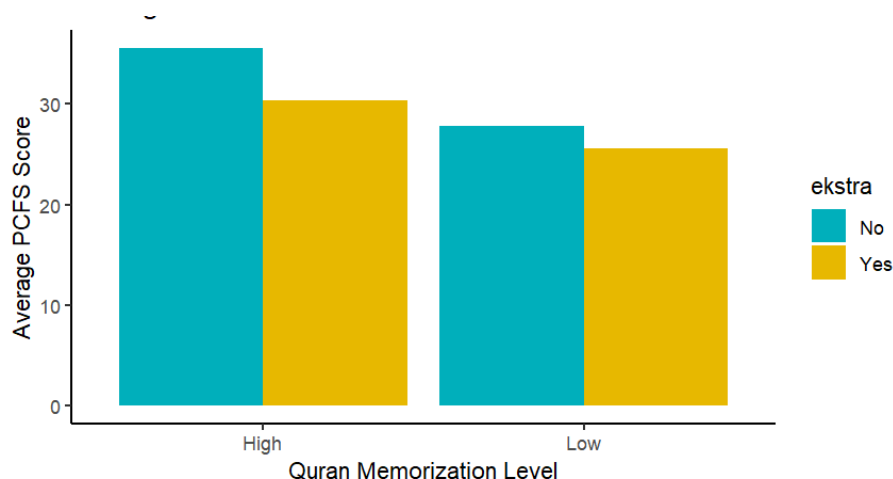


Figure 3. Average PCFS Score based on Memorization and Extracurriculars

Students with higher Qur'an memorization loads (more than two juz per semester) experienced higher fatigue levels, even after adjusting for study hours and sleep. A regression model showed that high memorization goals were associated with an average increase of 6.1 PCFS points ($p = 0.015$). This outcome suggests that repetitive, memory-intensive tasks may exhaust students' cognitive reserves more than time-on-task alone. Prior research supports this hypothesis, indicating that tasks demanding rote memorization over extended periods place significant demands on working memory and lead to mental fatigue (Kaur et al., 2018). Therefore, while memorization is central to the religious curriculum, its intensity should be moderated to preserve students' cognitive health.

To validate self-reported fatigue, students completed a 2-back task assessing working memory and sustained attention. Accuracy dropped from 87.4% among those studying less than 8 hours to 72.8% for those studying more than 12 hours. Furthermore, reaction time variability (RT-SD) increased by 42 milliseconds across these groups. Regression analysis showed PCFS scores significantly predicted RT-SD ($\beta = 0.36$, $p = 0.002$), supporting the behavioral validity of the scale. These results echo the findings of (Josev et al., 2020), who reported that high cognitive fatigue is reliably associated with declines in attention performance and response consistency in adolescent populations under stress.

Gender and age were analyzed as potential moderators in the relationship between study load and cognitive fatigue. However, interaction effects were non-significant ($p > 0.10$), suggesting neither variable played a significant role in altering fatigue outcomes. Although female students had slightly higher mean PCFS scores (51.9 vs. 49.4 for males), the difference was not statistically significant ($t = 1.02$, $p = 0.31$). Similarly, no age subgroup showed significantly higher fatigue levels.

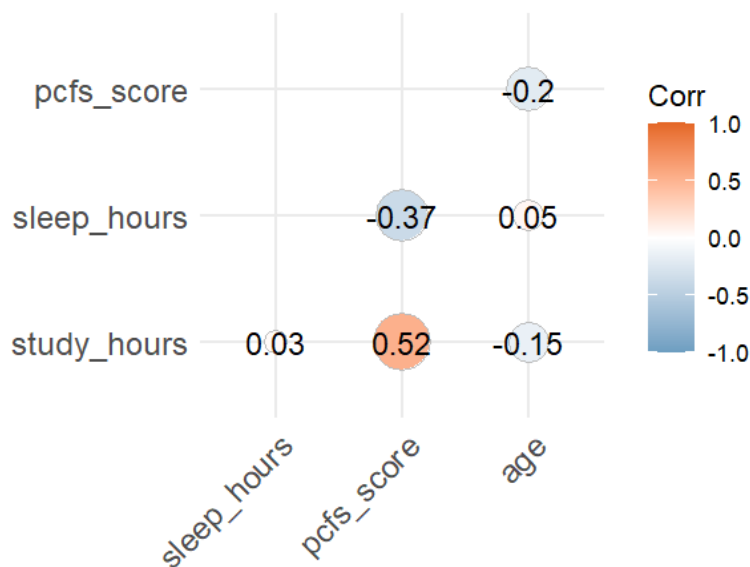


Figure 4. Correlation between Numerical Variables

findings that demographic variables like gender and age had minimal influence on academic fatigue among secondary students in Indonesia. Interestingly, students who participated in light extracurricular activities such as calligraphy, art, or discussion clubs reported significantly lower fatigue. On average, their PCFS scores were 5.2 points lower ($p = 0.028$), even after controlling for other variables like study hours and sleep. These results showed that breaks involving non-academic, creative activities help restore attention and reduce mental overload. In the context of a boarding school with a dense academic and religious schedule, these activities serve a valuable recovery function and should be formally integrated into daily timetables.

The final multivariate regression model included study hours, sleep duration, memorization load, and extracurricular participation. Together, these variables accounted for 62% of the total variance in PCFS scores (adjusted $R^2 = 0.62$, $F(4,115) = 50.2$, $p < 0.001$). Standardized beta coefficients ranked predictors as follows: study hours ($\beta = 0.48^{***}$), sleep duration ($\beta = -0.34^{***}$), memorization load ($\beta = 0.22^*$), and extracurricular participation ($\beta = -0.17^*$). These findings quantitatively reinforce the multifactorial nature of cognitive fatigue and highlight specific levers particularly sleep and extracurricular activities that may buffer against fatigue even in high-demand environments.

To determine a meaningful threshold for intervention, a Receiver Operating Characteristic (ROC) curve was generated using PCFS scores against cognitive task performance. A cut-off of 55 was identified, yielding 81% sensitivity and 78% specificity for predicting high fatigue with behavioral consequences. At this threshold, 38.3% of the students were classified as experiencing high cognitive fatigue. This high-risk group was disproportionately represented in the >10 hours/day study brackets. Who found that students in similar dual-curriculum boarding schools showed fatigue-related declines in academic motivation and cognitive resilience.

Discussion

The present study provides strong empirical evidence that cognitive fatigue is a prevalent issue among students enrolled in dual-curriculum Islamic boarding schools. Our findings demonstrate a clear dose-response relationship between daily study hours and levels of cognitive fatigue, as measured by the Pediatric Cognitive Fatigue Scale (PCFS). Specifically, students who studied more than 12 hours per day reported significantly higher PCFS scores compared to those studying fewer than 8 hours. This trend aligns with international literature, including the work of (Blair, 2017; Jirout et al., 2019; Ropovik, 2014), which links excessive cognitive demands with mental fatigue and diminished executive functioning in school-aged children. These findings emphasize the urgent need to address workload management in faith-based education environments that combine religious and secular instruction.

A key moderating factor in this study was sleep duration, which was negatively correlated with fatigue levels. Students who slept fewer hours particularly those studying more than 12 hours per day reported higher PCFS scores, supporting findings by (García et al., 2021), who noted that sleep deprivation significantly impairs cognitive control and working memory in adolescents. In our regression model, sleep duration independently explained 14% of the variance in fatigue scores beyond study hours. These results underscore the neurobiological need for adequate rest during adolescence, when the brain undergoes rapid development. Thus, interventions aiming to reduce cognitive fatigue must include structured routines that enforce sufficient sleep, especially in settings like pesantren where daily schedules are often rigid.

The study also found that heavy Qur'anic memorization loads significantly contributed to elevated fatigue scores. Students memorizing more than two juz per semester experienced higher cognitive fatigue, even when controlling for total study time and sleep. This suggests that the nature of the task repetitive and memory-intensive may have unique fatigue-inducing effects. Similar conclusions were drawn by (Sweller et al., 1998, 2019), who documented how intense rote memorization can deplete attentional resources and inhibit long-term retention. Although memorizing the Qur'an is a foundational aspect of Islamic education, its demands must be balanced with students' cognitive health, particularly when combined with parallel general education coursework.

In addition to self-report measures, the use of a 2-back working memory task added behavioral validity to the findings. As fatigue levels increased, performance on this task declined both in accuracy and reaction time consistency. These outcomes substantiate previous findings by (Behrens et al., 2023b), who demonstrated that high levels of cognitive fatigue result in impaired attentional control and increased performance variability. This behavioral dimension lends credibility to the PCFS scale as a valid proxy for cognitive functioning, and it illustrates that fatigue is not merely a subjective experience but one with measurable impacts on academic and neurocognitive performance.

Interestingly, students who engaged in extracurricular activities such as arts or discussion groups reported lower PCFS scores, indicating that mental recovery mechanisms are essential in high-demand environments. These findings are consistent with those of (Goble et al., 2021), who emphasized the restorative benefits of creative and non-academic engagements for adolescents. In the context of pesantren, where time is heavily scheduled, even minimal participation in such activities provided noticeable relief from fatigue. These results highlight an actionable opportunity: incorporating structured, restorative time into students' schedules to buffer the effects of prolonged mental effort and promote long-term learning sustainability.

From a policy standpoint, these results call for a re-evaluation of educational schedules within pesantren. Institutions should reconsider the assumption that longer study hours equate to better outcomes. Instead, the findings align with cognitive load theory (Sweller et al., 2019), suggesting that excessive workload undermines cognitive efficiency and learning retention. Educational leaders must develop balanced schedules that optimize mental performance rather than maximize instructional hours. Integrating sleep education, time management training, and cognitive breaks into the curriculum could be effective strategies to reduce fatigue without compromising academic rigor or religious commitments.

While these recommendations are grounded in empirical findings, it is important to contextualize them within the cultural and religious values of pesantren. The emphasis on discipline, endurance, and religious devotion may create resistance to change. As such, interventions should be culturally sensitive and framed as efforts to preserve not weaken students' ability to memorize, learn, and serve their faith. Stakeholder engagement, including collaboration with religious leaders, teachers, and parents, will be essential to developing strategies that are both effective and acceptable within the pesantren framework.

These findings also invite broader comparison with other educational systems where dual curricula are implemented. Studies in countries such as Malaysia and Egypt have reported similar challenges (Tayeb, 2018), reinforcing the idea that the cognitive burden of balancing religious and academic study is a systemic issue, not unique to Indonesia. However, our study contributes novel behavioral and multivariate data that deepen the understanding of how these burdens manifest cognitively. Such comparisons may help formulate universal guidelines for dual-curriculum education systems worldwide, particularly those operating within boarding school structures.

This study benefits from a robust mixed-methods approach that includes both subjective and objective measures of cognitive fatigue. The use of a validated scale (PCFS), behavioral tasks, and regression modeling strengthens the validity of our conclusions. However, several limitations must be acknowledged. First, the cross-sectional design prevents causal inference. Second, the study was limited to one pesantren, which may affect generalizability. Third, although behavioral validation was included, neurophysiological measures such as EEG or cortisol levels could offer deeper

insight into the biological basis of fatigue. Future studies should consider longitudinal designs and multisite sampling for broader applicability.

CONCLUSION

This study investigated the prevalence and predictors of cognitive fatigue among santri attending dual-curriculum Islamic boarding schools, with a focus on study duration, sleep quantity, and memorization load. The findings reveal a clear dose-response relationship: longer study hours and heavier Qur'anic memorization are significantly associated with higher fatigue scores, while reduced sleep exacerbates this condition. These results are supported by both self-report scales and behavioral task outcomes, indicating that the impact of fatigue extends beyond perception into measurable cognitive performance decline.

The implications are significant for educational policy in pesantren environments. Institutions must reconsider overly demanding schedules and implement balanced routines that account for students' cognitive limits. Integrating structured rest, optimizing memorization methods, and protecting sleep time are vital strategies for preserving mental health and learning effectiveness. Failure to address these issues could compromise not only academic performance but also spiritual engagement, emotional regulation, and long-term well-being.

While the study was limited by its cross-sectional design and single-site focus, it provides a strong foundation for future research. Longitudinal and multisite investigations are needed to explore the chronic effects of sustained fatigue, as well as potential protective interventions. Educational innovation particularly culturally contextualized, data-informed scheduling will be essential to ensure that dual-curriculum boarding schools foster both intellectual achievement and holistic student development

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