

Impact of Information Overload on Cognitive Fatigue, Psychological Well-Being and Academic Outcomes

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Abstract

The higher education sector has gone through tremendous transformation which has enhanced the use of digital technologies and online learning platforms operated by artificial intelligence. These technology has not only given a better learning environment, it also creates a certain amount of pressure which results in stress among the students. This study aims to analyse the interrelationships between techno-stress, attention difficulties, psychological effects with cognitive fatigue among the undergraduate students in digital mediated learning environments. Quantitative correlational research was used and grounded on the theories of Cognitive Load Theory and Information Processing Theory. It looked at the cognitive effects and psychological effects of prolonged use of digital devices. The data was collected using a structured questionnaire 121 undergraduate engineering students aged 17–23 years through purposive sampling. The techno-stress, attention and learning difficulties, cognitive fatigue and psychological effects were measured. The Statistical Package for the Social Sciences (SPSS) was used to analyze the data with descriptive statistics, reliability analysis, Pearson correlation and multiple regression analysis. As per the results, techno-stress ($M = 14.40$), cognitive fatigue ($M = 13.83$), attention-related problems ($M = 14.16$), and psycho-affective repercussions ($M = 14.84$) resulted moderate level. Prior research has established a strong correlation between cognitive fatigue and techno-stress, which refers to anxiety and impairment of daily functioning caused by technology disruptions. The study indicates prolonged digital learning overloads students' brain, exhausts them mentally, makes them inattentive, and induces psychological strain.

1 INTRODUCTION

The 21st century is extravagantly drawn towards technology. From the moment humans wake up until they go to sleep, they are exposed to numerous data and information through ample modes like emails, texts, news updates, social media notifications, advertisements, and messages, and many more. This fast-moving world requires convenience in every aspect. In the realm of education, there has been a significant evolution in teaching methods and strategies, leading to a shift from favoring teachers to preferring students' convenience in teaching. The emergence of AI and digital tools, including e-learning platforms, interactive applications, and AI-driven tutors, draws attention towards them as it enables personalized learning experiences, at most flexibility and most importantly, the demanded output, which makes the users learn and respond immediately. These technologies also include interactive sessions for every individual and virtual classrooms that break the geographical barriers for the learners to learn whatever they need from every corner of the world. The emergence of these technologies and amenities has not only brought light into the lives of the students and teachers but also for the manufacturers and producers who receive a massive benefit in producing these appliances.

In the educational sector, the continuous expansion of digital forms has contributed to increasing the attention span of students. As the young generation is attracted to digital teaching and learning tools, the educationalists have incorporated these teaching tools into the curriculum to make the learning and teaching experience ahead of the curve. The teachers also prefer using these technologies, as they are exceptional in locating the sources and could be personalized according to the needs of the students. Which reduces the work of a tutor to individually teach or concentrate on students who lie in the zone of proximal development. Research has proved that personalization of teaching methods has exceptionally increased the learning and memory of the students.

Though all these are important to learn about current affairs, they take control over humans. Christian Lous Lange asserts that "technology is a useful servant but a dangerous master." This is because of the teaching tools that immerse users in using beyond reasonable limits. To support this study and substantiate that the students suffer from the impact of information overload, a questionnaire was set for the tutors regarding the progress of their students' technostress, cognitive fatigue, psychological effects, and learning consequences while using technology. And strengthen the study psychologically with a summary of five case studies after counseling the patients aged 17 to 20.

The present study aims to critically analyze the impact of information overload and over use of modern educational technologies on undergraduate students' cognitive functioning and psychological well-being. Specifically, the study investigates how techno-stress, attention difficulties, and psychological effects contribute to cognitive fatigue among undergraduate learners in digitally mediated academic environments. To achieve this aim, based on existing theoretical and empirical studies, the researchers formulated the following specific objectives:

1.1 RESEARCH OBJECTIVES

1. To examine the extent of digital learning engagement and the level of techno-stress experienced by undergraduate students in digitally mediated learning environments.
2. To investigate the relationship between techno-stress and attention difficulties and learning challenges among undergraduate students.
3. To analyze the association between techno-stress, attention difficulties, cognitive fatigue, and psychological effects among undergraduate students.

2 THEORETICAL FRAMEWORK

The basis of the study in this paper relies most heavily on Cognitive Load Theory (CLT) proposed by John Sweller. Moreover, it also includes the Information Processing Theory as an extension of CLT. Both explain the excessive use of digital communication, which hampers learning and cognition. According to Cognitive Load Theory, humans have limited processing capacities for information. Cognitive overload is the result of extensive exposure to digital information, multitasking, online learning, and AI-assisted learning tools. This cognitive overload ultimately results in cognitive fatigue and learning inefficiencies. The present study reflects that technostress, attention problems, and psychological symptoms are linked with high extraneous cognitive load due to overuse of technology-led academic environment. Just like that, Information Processing Theory states that learning happens when a learner is capable of receiving and processing and storing and retrieving information by the attention and working memory systems. Being exposed to such technology for a long time has adverse effects on the brain. It affects the cognitive processes which help us in concentrating. Therefore, that leads to slower processing

speed, memory consolidation failure, and mental fatigue. The excessive flow of information that requires a lot from students intellectually will lead to phenomena like anxiety, irritability, emotional overload, and reduced emotional self-awareness may emerge when students' cognitive capacities are continuously strained by excessive information exposure.

Grounded in Cognitive Load Theory, Information Processing Theory, and empirical evidence suggesting that excessive digital exposure influences cognitive and emotional functioning, the present study proposes the following hypotheses:

2.1 HYPOTHESES

H1: Undergraduate students spend most of their time in digital learning, so students experience moderate levels of technostress.

H2: Technostress among the undergraduate students leads to attention difficulties and learning challenges in digitally mediated learning environments.

H3: Technostress and attention difficulties are positively associated with cognitive fatigue and psychological effects among undergraduate students.

2.2 LEARNING AND COGNITION

Learning is a process of gradual change. This change has been inevitable since the birth of humans. Learning involves both acquiring new information and modifying existing knowledge structures. The cognitive perspective views learning not as a passive absorption of information but as an active mental process involving attention, encoding, storage, retrieval, and application. The process of learning refers to the steps through which individuals acquire knowledge, skills, attitudes, and values. It involves the interaction of cognitive, emotional, and environmental influences that shape understanding and behavior. Learners assimilate new experiences into existing cognitive structures and accommodate their mental models to make sense of new information. So, this is how children actively construct knowledge through stages as their cognitive abilities mature (Piaget, 1972).

Learning and cognition are central to understanding how humans acquire knowledge, develop skills, and adapt to their environment. These two processes are deeply intertwined, as cognition provides the mental functions necessary for learning, while learning continuously shapes cognitive structures and capabilities (Anderson, 1990). Cognition refers to the set of mental processes that include attention, perception, memory, language, problem-solving, and reasoning. These processes enable individuals to understand and respond to the world around them. Learning, on the other hand, is defined as a relatively permanent change in behavior or knowledge that results from experience or practice (Ormrod, 2011).

Psychologists and educationalists have found the mental process of learning and cognition, but this very process needs learning or cognitive tools that enhance the quality of learning and help in better retention of the memory. Cognitive tools refer to technological or symbolic tools that support, enhance, or extend human thinking and learning processes. "Cognitive tools are computer-based tools that have been adapted or developed to function as intellectual partners with the learner in order to engage and facilitate critical thinking and higher-order learning." These tools do not teach directly but help learners to construct knowledge by engaging in higher-order cognitive tasks such as analysis, synthesis, problem-solving, and critical thinking. (Jonassen, 1996)

2.3 COGNITIVE FATIGUE AND OTHER CONSEQUENCES

Cognitive fatigue is defined as a state of mental exhaustion that results from sustained cognitive activity, especially when it requires constant attention switching, decision-making, and information processing. With learners frequently alternating between digital tools (e.g., attending a Zoom class while checking Google Classroom notifications), cognitive load increases significantly. (Sweller, 1986)

The technology has paved the way to enhance the learning process by introducing e-learning and computer-based teaching, which makes learning easy, interactive, and possible at any time and location, which are crucial factors. Technology has always been a double-edged sword with unintended drawbacks, especially in an educational context. In recent years, e-learning has apparently become more prominent in modern society as technological advances took place (Nardi & Ranieri, 2018). E-learning is a common method since it is able to present the content of the course in a longer period of time compared to classroom environments and other methods; it allows education for seven days and twenty-four hours; it reaches a greater number of learners; and it ensures a learning environment that is independent of time and place (Dziuban, Hartman, & Moskal, 2004; Osguthorpe & Graham, 2003).

This leads to the deliberate use of electronic devices with advanced technologies, which makes learners dependent. The educational institutions load the students with work due to the easy accessibility of information. Technological tools such as Zoom, Google Meet, Microsoft Teams, and learning apps like Khan Academy and Quizlet have become integral to modern education. However, while these tools may have ample benefits, it's not limited to that alone. These tools tend to load the students with a high amount of information, and a prolonged cognitive process takes place. (Sana et al., 2013)

Technological tools have evolved deliberately for each type of use and benefit. Tech entrepreneurs and app developers have analyzed the broader utility of the users and created ample apps to take the pressure off and knock the brains out of service Kim (2012). Concept mapping tools such as CmapTools, MindMeister, and Lucidchart may lead to cognitive overload if too many elements are added without structure. Over-focusing on design/layout may distract from actual content learning. Some students may struggle with abstract visualization, leading to frustration. (Chiou, 2017) (Duarte, E. C. et al., 2017)

For creating spreadsheets and databases Microsoft Excel, Google Sheets, and Airtable are used. Using complex formulas and functions can cause mental fatigue in students not trained in data literacy (Norman, 1988/2013). Heavy emphasis on data entry or formatting can detract from conceptual understanding. Interface complexity may overwhelm beginners, slowing learning (Malinski, 2013). Multimedia authoring tools like Microsoft PowerPoint, Canva, and Adobe Spark may make students spend excessive time on aesthetics and design, neglecting deeper content learning. Visual overstimulation with too many fonts, animations, transitions can hinder cognitive processing. Requires multitasking like design, writing and editing which may exhaust working memory. (Mayer & Fiorella, 2021)

Simulation and Virtual Lab Tools like PhET Interactive Simulations, Labster, and GeoGebra can become mechanical or passive if learners simply click through without reflection. High interactivity and animations may lead to sensory overload or distract from core concepts. These apps require strong internet and device capability. Technical failures can reduce engagement and cause frustration (Waldrop, 2013). One of the most important tasks of organization is also done using mind mapping & brainstorming software like XMind, Bubbl.us, and Miro. These apps can lead to unstructured brainstorming, which may result in mental clutter instead of clarity. It can also overwhelm students if they try to map too many ideas without guidance. Excessive cognitive effort is required to organize and rearrange thoughts, which can tire learners (Davies, 2010).

Technological apps which threaten the extinction of the face-to-face teaching mode by providing facilities to tutors and monitoring the students without even getting to know the students personally. Intelligent Tutoring Systems like Carnegie Learning and ALEKS may lead to isolation and reduced human interaction, affecting motivation and emotional learning (Banda & Robinson, 2011). Feedback can be impersonal or overly repetitive, causing boredom or disengagement. Overuse of adaptive pacing can slow learners down, making them overly dependent on system feedback (VanLEHN, 2011).

The main aim of language acquisition is to learn the grammatical aspects and the LSRW skills; only then does the act of learning a language become complete, but the technology has interrupted the process of learning and limits or even stops the learners from learning. Writing and research tools like Grammarly, Zotero and Google Docs tools like Grammarly can discourage self-editing skills, making students passive writers. Relying on Zotero may cause learners to skip understanding citation logic. Real-time editing and collaboration in Docs may result in distractions and interruptions. The unequal access to digital tools and the significant differences in skill levels among students create an imbalance during the teaching phase of teachers' responsibilities. The risk of a "digital tools as toys" mentality among students, lack of critical thinking skills in their middle and high school students, and an inadequate definition among students of what forms "writing" (K. Purcell et al., 2013).

According to Greipl et al. (2020) in *Potential and Limits of Game-Based Learning*, it highlights that despite its motivational appeal, game-based learning (GBL) has several disadvantages. Game-based learning tools such as Kahoot, Quizizz, and Classcraft can lead to superficial engagement, where learners focus more on game mechanics than on content, limiting deep understanding. Excessive gamification may cause cognitive overload, reducing the effectiveness of learning. The reward-based structure can undermine intrinsic motivation, shifting attention from mastery to performance. Additionally, not all learners respond equally well to gamified environments, and poorly designed games may result in frustration or disengagement. Purpose: Promote engagement and memory retention through interactive quiz formats and gamification. Besides motivation, engagement and affect, cognitive aspects like learning outcomes, visual perceptual ability, or attention are the most widely evaluated aspects of game-based learning (Boyle et al., 2016).

While OneNote, Notion, and Evernote are valuable for organizing information, they present several disadvantages. Their complex features can overwhelm learners, cause cognitive overload, and reduce their focus on actual learning. Students may prioritize formatting and structure over comprehension, leading to superficial engagement with content. Over-reliance on these tools Digital distractions may hinder the development of traditional notetaking and memory retention skills (Mueller & Oppenheimer, 2014). Additionally, syncing issues, internet dependency, and potential data privacy concerns can disrupt accessibility and security. Distractions from multimedia integration or collaborative features may further reduce productivity. These risks demonstrate the importance of balanced use and proper guidance when incorporating digital note-taking tools in education.

All these technologies and simplified apps do not make the work easy for the students, as in the beginning it may appear so but slowly leads to prolonged screen time and more cognitive load. When learners are exposed to prolonged or intense cognitive tasks without adequate breaks or recovery, they may experience cognitive fatigue—a mental state marked by reduced efficiency, attention, and motivation (Boksem & Tops, 2008). This usage is positively associated with technostress, which is stress caused by information and communication overload (Ragu-Nathan et al., 2008).

According to Arnsten (2009), during cognitive fatigue, the prefrontal cortex (which is involved in learning, decision-making, and executive control) becomes less active. This impairs the consolidation of new learning, making neuroplastic changes less efficient or even reversed in the case of stress-related overload. This state can impair the very neural processes that support neuroplasticity.

2.4 NEUROPLASTICITY AND COGNITION

Neuroplasticity refers to the brain's ability to reconstruct itself by forming new neural connections throughout life. Neuroplasticity is the brain's ability to change and adapt structurally and functionally in response to experience, learning, or injury. It involves the strengthening or weakening of synaptic connections, the growth of new neurons, and the reorganization of neural pathways. This adaptability enables individuals to acquire new skills, recover from brain damage, and adjust to changing environments. Neuroplasticity occurs throughout life, though it is more rapid during childhood. It plays a critical role in learning, memory, and behavioral development (Doidge, 2014).

Contrary to earlier beliefs that the brain becomes static after childhood, modern neuroscience confirms that neuroplasticity continues into adulthood, enabling individuals to adapt to new learning experiences, recover from brain injuries, and adjust to environmental changes (Pincus, 2008). Neuroplasticity is important not just for learning new things and skills but also for changing how a learner feels about the learning process and what motivates them. Motivation, broadly defined as the processes that initiate, guide, and sustain goal-directed behaviors, significantly impacts how we attend, remember, problem-solve, and learn. Maslow's well-known "Hierarchy of Needs" (1943) implies a definition of motivation as the drive to fulfill a series of innate human needs, ranging from basic physiological survival to self-actualization. He argued that individuals are motivated to satisfy lower-level needs before higher-level needs become salient (Maslow, 1943). New research shows that the way students see their own skills and deal with problems has a direct effect on and is affected by changes in the brain's neuroplasticity.

In the context of learning, neuroplasticity is fundamental. Each time students engage in meaningful cognitive activities—such as reading, problem-solving, or critical thinking—the brain strengthens related neural pathways. This repeated stimulation improves memory, cognitive flexibility, and skill acquisition (Draganski et al., 2004). However, with the widespread integration of technology in education as mentioned above, concerns have emerged regarding its

potential to hinder neuroplastic development. While digital tools like learning management systems, grammar checkers, and note-taking apps can support learning efficiency, excessive or passive use may reduce the cognitive effort required for deeper learning. For example, tools such as Grammarly automate grammar correction, reducing the need for students to engage in the metacognitive process of self-editing. This can inhibit the reinforcement of language-related neural pathways and reduce long-term retention (Rafiq et al., 2024).

From a neuroscientific viewpoint, motivation activates the dopaminergic system in the brain, particularly the mesolimbic pathway, which is involved in reward anticipation and reinforcement learning. When individuals are motivated—either intrinsically or extrinsically—their brains release dopamine, a neurotransmitter that enhances attention, promotes memory consolidation, and encourages goal-directed behavior. These processes are crucial for cognitive flexibility, learning efficiency, and long-term retention (Lisman et al., 2011).

Functional imaging studies have shown that motivational states activate regions such as the prefrontal cortex and anterior cingulate cortex, which are involved in executive functions like decision-making, emotional regulation, and cognitive control. Motivation essentially acts as a neuromodulator, optimizing the allocation of cognitive resources during tasks requiring focus and effort (Pessoa, 2009).

Psychologically, motivation is considered a driving force behind behavior and learning. Self-determination theory highlights the importance of intrinsic motivation—engaging in a task for its own sake—versus extrinsic motivation, which is driven by rewards or punishments. Research shows that students with higher intrinsic motivation tend to perform better cognitively, show more resilience, and engage in deeper learning strategies (Deci & Ryan, 1985).

Attitude, which encompasses beliefs, emotions, and predispositions toward objects or tasks, also significantly influences cognition. A positive attitude toward learning enhances metacognition (awareness and regulation of one's own thinking), encourages perseverance, and reduces cognitive stress. Conversely, a negative or anxious attitude can trigger amygdala activation, which interferes with hippocampal functioning and impairs memory and learning (Davidson & McEwen, 2012). Additionally, expectancy-value theory posits that individuals are more likely to engage in cognitive tasks when they expect success and value the outcome. Thus, both motivation and attitude affect not only whether a person chooses to engage cognitively but also how effectively they process information (Wigfield & Eccles, 2000).

2.5 THE PSYCHOLOGICAL IMPACT OF PROLONGED DIGITAL MULTITASKING

One of the major consequences of prolonged digital multitasking is attention fragmentation. Studies have shown that digital multitasking reduces sustained attention and increases susceptibility to distractions. This constant shifting between tasks limits deep thinking and reduces the brain's ability to filter irrelevant information, causing mental fatigue. Over time, users may find it difficult to concentrate on single tasks, even when not using technology (Ophir et al., 2009). Prolonged digital engagement is also linked to increased stress and anxiety. The pressure to respond quickly to multiple digital inputs, including notifications from AI-based productivity or communication apps, creates a state of continuous partial attention. This condition is mentally exhausting and associated with elevated cortisol levels, a stress hormone. Furthermore, AI applications that offer decision-making support, such as virtual assistants or recommendation systems, can cause decision fatigue by presenting too many options or encouraging constant micro-decisions. AI chatbots and productivity tools, while useful, can create a false sense of urgency, reinforce unhealthy work habits, and reduce opportunities for meaningful breaks. (Mark et al., 2008).

Another significant psychological issue is the decline in emotional regulation and increased risk of burnout. Continuous use of digital tools can overstimulate the brain's reward system, especially through applications designed to promote constant engagement (like social media platforms powered by AI algorithms). This overstimulation can lead to emotional exhaustion, irritability, and mood disorders (Rosen, Lim, Carrier, & Cheever, 2011). Reduced empathy and social disconnection are growing psychological concerns linked to the excessive use of digital and AI communication tools. As individuals, particularly adolescents and young adults, increasingly interact through screens, their ability to engage in face-to-face communication diminishes. The lack of physical cues such as tone, gesture, and expression can weaken emotional understanding and interpersonal bonds. Over time, this shift fosters shallow relationships and a decline in empathy, leading to increased feelings of loneliness and isolation. Encouraging real-life social interactions and emotional literacy is essential to counteract these negative effects and maintain healthy social and emotional development (Uhls, 2017).

According to Nakshine et al. (2022), dependency on digital devices contributes to heightened stress and anxiety, often resulting from disrupted sleep, over-arousal, and exposure to negative or emotionally provocative content. Prolonged use frequently induces a state of hyper-arousal, elevating stress hormones like cortisol, which impairs emotional regulation and drains mental energy. Screen overexposure also desynchronizes circadian rhythms, altering brain chemistry, and aggravating mood instability and mental fatigue. Supplementary research highlights how excessive screen use amplifies psychological distress, particularly among adolescents. Studies indicate that over 3 hours per day of leisure-based screen time is linked to elevated future risk of depression, anxiety, and emotional disorders—unlike equivalent durations spent on non-screen sedentary activities. Problematic smartphone use correlates with low self-esteem, social isolation, and FOMO (Fear of Missing Out)-related anxiety, especially in younger users subject to social comparison in online environments.

2.6 CONSEQUENCES FOR LEARNING OUTCOMES AND MENTAL HEALTH

All these symptoms are collectively coined as "technostress" by the American psychotherapist Craig Brod as "a modern disease of adaptation caused by an inability to cope with the new computer technologies in a healthy manner." (Brod, 1986). The term "technostress" has existed since 1986 but was found only among the work sector that constantly used evolving computers and technologies (P. L., 1982). Technostress is "any negative impact on attitudes, thoughts, behaviors, or body psychology caused directly or indirectly by technology" (Michelle M. & Larry D., 1997) (p. 36). According to Caro and Sethi (1985), technostress is "a perceived, dynamic adaptive state between the person and the environment, mediated by sociopsychological processes and influenced by the nature of the technological environment."

Further research on this term brings many other factors that contribute to technostress, like techno-overload, techno-invasion, techno-complexity, techno-insecurity, and techno-uncertainty (Tarafdar et al., 2007) (Chen, 2015). This paper will further explore the techno-overload, psychological impacts, and emotional well-being in detail. In the organizational context, Tarafdar et al. (2007) indicated that technostress is caused by individual attempts and struggles to cope with constantly evolving Information and Communication Technologies (ICT) and the changing physical, social, and cognitive requirements related to their use. The authors explain that technostress is a phenomenon arising from the demands during the usage of technology and its applications that generate stress.

The research article by Lei and Ngai (2014) states that, according to the transactional theory of stress, technostress can lead to both negative and positive outcomes. In this regard, Tarafdar et al. (2019) indicated that stress embodies the condition of imbalance experienced by an individual between the demands of a situation and the ability to fulfill them. All human beings do not give the same reaction to certain internal or external alterations; hence, two concepts arise: techno-eustress and techno-distress. Techno-eustress is positive stress that causes satisfaction and joy, increases vitality, does not cause imbalances, and helps facilitate people's decision-making (Tarafdar et al., 2019). If limited and proper use of technology is given, it allows humans to develop the skills and bring them out at most levels of talent. In accordance with Salazar-Concha et al. (2021), technostress can cause risk in the long term; overload of information is created and can, therefore, be stressed, causing harm to his health. The worker will have greater personal development thanks to the stress; however, it will probably be based on the detriment of her health. Therefore, excessive use or dependency on technology should be avoided.

Excessive multitasking with digital devices can negatively impact attention and working memory. Constant exposure to screen-based distractions such as social media notifications, video content, and app-switching fragments attention spans and reduces the brain's capacity to focus on complex tasks. This kind of behavior is associated with a decline in executive functions, such as sustained attention and cognitive control, which are crucial for learning and brain development (Loh & Kanai, 2016).

Prolonged digital multitasking can impair the development of the prefrontal cortex, the region responsible for decision-making and impulse control, thereby weakening the very neural circuits that neuroplasticity aims to enhance. Moreover, the use of adaptive learning technologies, while beneficial in some contexts, can make learners overly reliant on system feedback. This passive mode of engagement may reduce opportunities for productive struggle—an essential component of deep learning that stimulates neuroplasticity (VanLEHN, 2011).

When students cannot retrieve, reflect, and self-correct, the neural effort required for long-term memory is disturbed, which results in shallow learning. This does not stop here but rather leads to psychological problems, which affect their motivation and attitude towards learning and cognition.

3 METHODOLOGY

3.1 RESEARCH DESIGN

This study has adopted a quantitative research design to investigate the relationship between techno-stress, cognitive fatigue, attention difficulties, and psychological effects among undergraduate students. Data were collected through a structured questionnaire administered and facilitated to 121 undergraduate students using a five-point Likert scale. The reliability of the instrument was established through Cronbach's alpha, which indicated high internal consistency. Descriptive statistics, Pearson correlation, and multiple regression analyses were employed to analyze the data and examine the relationships among the study variables with respect to the Cognitive load theory. The focus of the study was to investigate the presence of moderate levels of techno-stress, cognitive fatigue, attention difficulties, and psychological effects, with significant positive relationships among these variables and cognitive fatigue.

3.2 WORKING GROUP

The participants of the study were 121 undergraduate engineering students between the ages of 17–23 years, using purposive sampling. The reason that engineering students were chosen as participants is that engineering students are usually exposed to a greater degree of digital learning, online resources, educational software, and technology mediated academic activities as compared to other university students.

3.3 DATA COLLECTION TOOLS

A structured questionnaire having demographic items and Likert-scale statements was used to gather data regarding techno-stress, problems with paying attention and learning, cognitive fatigue, and psychological effects. The data collected were coded and analyzed with the help of the SPSS software package. To assess the reliability of the instrument, Cronbach's alpha reliability analysis was conducted with a satisfactory reliability coefficient. The frequencies, percentages, means, and standard deviations of the study variables were acquired through descriptive statistics. The relationships among techno-stress, difficulties in attention, cognitive fatigue and psychological effects were analysed using a Pearson correlation analysis. Furthermore, the multiple regression analysis of the techno-stress, difficulties in attention and psychological effects on cognitive fatigue was also carried out.

3.4 DATA ANALYSIS

Table 1
Testing Reliability of the
Questionnaire:

Reliability Statistics	
Cronbach's Alpha	N of Items
0.886	22

The 22-item scale exhibited high internal consistency, with a Cronbach alpha coefficient of 0.886 from 121 respondents. With a score that goes above the acceptable threshold for academic research, 0.70, this indicates strong reliability.

Table 2
Frequency table:

		Frequency of Using Digital Tools for Academic Learning				
		Rarely	Sometimes	Often	Always	Total
Gender	Female	0	8	22	12	42
	Male	7	24	35	13	79
Age	17–18	4	20	35	16	75
	19–20	3	12	16	5	36
	21–22	0	0	1	1	2
	Above 22	0	0	5	3	8
	Total	14	64	114	50	121
Note. This table demonstrates the use of digital tools for academic learning with respect to gender and age.						

Table 3
Internet Accessibility

		Internet Accessibility for Academic Work					
		Very Limited	Limited	Moderate	Good	Excellent	Total
Gender	Female	3	5	9	20	5	42
	Male	9	6	20	33	11	79
Age	17–18	7	3	21	33	11	75
	19–20	5	8	6	15	2	36
	21–22	0	0	1	1	0	2
	Above 22	0	0	1	4	3	8
Total		24	22	58	106	32	121
Note. This table reports the frequency of internet accessibility for academic work with respect to gender and age.							

Table 4
Descriptive Statistics:

N	Techno-Stress Score	Cognitive Fatigue Score	Attention Difficulties Score	Psychological Effects Score
	121	121	121	121
Mean	14.40	13.83	14.16	14.84
Std. Deviation	3.065	3.254	3.912	4.299
Variance	9.391	10.589	15.300	18.483
Minimum	5	5	5	5
Maximum	25	25	25	25

Table 5
Correlation

		Techno-Stress Score	Attention Difficulties Score	Psychological Effects Score
Cognitive Fatigue Score	Pearson Correlation	.648**	.561**	.533**
	Sig. (2-tailed)	.000	.000	.000
	N	121	121	121

** . Correlation is significant at the 0.01 level (2-tailed)**

Pearson correlation revealed significant positive correlations between Cognitive Fatigue Score and all three predictor variables. Cognitive Fatigue showed a strong positive correlation with Techno-Stress Score ($r = 0.648, p < 0.001$), indicating that higher levels of techno-stress were associated with greater cognitive fatigue. Moderate positive correlations were also observed with Attention Difficulties Score ($r = 0.561, p < 0.001$) and Psychological Effects Score ($r = 0.533, p < 0.001$), suggesting that increased attention difficulties and psychological effects were related to higher levels of cognitive fatigue.

Table 6
Multivariate Regression:

Predictor	Unstandardized Coefficients (B)	Std. Error	t	p-value	95% CI for B
Constant	2.297	1.070	2.148	0.034	0.179–4.415
Techno-Stress Score	0.516	0.080	6.438	< 0.001	0.357–0.674
Attention Difficulties Score	0.248	0.087	2.851	0.005	0.076–0.421
Psychological Effects Score	0.040	0.082	0.493	0.623	–0.122–0.202

The multiple linear regression model was statistically significant ($F = 40.719$), ($p < 0.001$) and explained 51.1% of the variance in Cognitive Fatigue Score ($R^2 = 0.511$); Adjusted ($R^2 = 0.498$). Techno-Stress Score emerged as the strongest significant predictor ($B = 0.516$), ($p < 0.001$), indicating that higher techno-stress was associated with increased cognitive fatigue. Attention Difficulties Score also significantly predicted cognitive fatigue ($B = 0.248$) ($p = 0.005$). However, the Psychological Effects Score did not show a significant independent contribution after controlling for the other predictors ($p = 0.623$). The Durbin–Watson statistic (1.918) indicated no substantial autocorrelation in the residuals, supporting the adequacy of the regression model.

4 SUMMARY OF THE FINDINGS

Results indicate that undergraduate students experienced moderate levels of techno-stress, cognitive fatigue, attention difficulty, and psychological impact in online learning. According to the results of the correlation analysis, techno-stress has a strong positive relationship with cognitive fatigue ($r = 0.648, p < 0.001$). A significant positive relationship was also found between attention difficulties and cognitive fatigue ($r = 0.561, p < 0.001$). Lastly, there was also a significant positive relationship between psychological effects and cognitive fatigue ($r = 0.561, p < 0.001$). Thus, techno-stress is strongly positively related with cognitive fatigue. Furthermore, this indicates students who mostly learn through digital means along with higher expectations from the institutions tend to suffer from mounting cognitive and emotional strain. In addition, the results were also found to be significant with respect to the prediction of the cognitive fatigue by the techno-stress and attention problems through multiple regression analysis. Moreover, techno-stress was found to be the strongest predictor ($B = 0.516, p < 0.001$). The model of regression indicated that the model exhibits a predictive effect of the selected variables as the R^2 value is 0.511. Nonetheless, $p > 0.05$ for our other controls what were applied. $p > 0.05$ is prominent when other.

Table 7
Hypothesis test results

Test	Hypothesis	Results	Interpretation
Frequency & Percentage	H1	Positive	The results show moderate to good use of digital learning platforms.
Multivariate Regression	H2	Positive	Technostress creates learning challenges and attention difficulties.
Pearson Correlation	H3	Positive	Indicate significant positive relationships between techno-stress and cognitive fatigue.

These findings provide empirical support for the view that excessive engagement with technology-based learning environments contributes to cognitive overload, resulting in increased mental exhaustion and reduced cognitive efficiency among undergraduate students.

5 DISCUSSION

The results show a moderate and considerable amount of cognitive fatigue due to the incorporation of digital learning platforms and their increased levels of expectations. With respect to the cognitive load theory, the study explores how students are constantly exposed to excessive information, multitasking, and regular technological demands, which turns their cognitive ability into a burden, thus resulting in cognitive overload, which reduces effectiveness and long-term memory. The study focuses on technostress, which is termed "extraneous cognitive load." This load specifies the mental effort caused by how the information is presented rather than the complexity of the information itself (intrinsic load). However, the results show a moderate level of cognitive fatigue; if the digital tools are appropriately used, it may lead to the creation of germane load.

The study indicates that technostress and attention difficulties are closely related. The result of the multivariate regression showed the strongest predictor ($B = 0.516, p < 0.001$) in this study. Also according to Ro'zimova, Feruza Shonazarovna (2026), indicate that prolonged digital exposure negatively affects attention, memory, and concentration, with prevalence ranging from 40% to 63% across different countries. This fragmentation of cognitive focus is particularly evident in the phenomenon of continuous partial attention, where the constant influx of digital notifications taxes executive control and degrades the capacity for sustained concentration (Shanmugasundaram & Tamilarasu, 2023) .

According to Atkinson and Shiffrin (1968), the information processing theory has three memory stores, the sensory memory, the working or short-term memory, and the long-term memory. These memory stores are stages in which the process of learning and cognition takes place with respect to the difficulty of the information and the presentation of information. During digital learning, students faced overwhelming information that creates cognitive load and results in disrupted working or short-term memory, and long-term memory is never attainable. Working memory has limitations when it comes to acquiring

information; this is further explored by Miller (1956), where he mentions that individuals can hold approximately seven units of information at a time. But later, Cowan (2001) found out that the actual capacity is closer to four meaningful chunks of information under most conditions. When more information is provided, the working memory is unstable and does not show positive results as expected.

The study of Rosen et al. (2018) shows that empirical evidence indicates that high-intensity engagement with digital environments significantly diminishes critical thinking skills and memory retention, as students find their executive functioning compromised by constant technological anxiety. Though digital learning has many benefits in learning, it contains many distractions and indirect problems, like anxiety and depression, motivational variables, the fear of missing out, emotional numbing, and procrastination, as well as an overreliance on technology.

Psychological Impact Model

6 CONCLUSION

The study aimed to examine the effect of techno-stress, attention difficulty, cognitive overload and psychological aspects among undergraduate engineering students in digitally mediated learning. Rooted in cognitive load theory and information processing theory, this study examines whether greater exposure to digital learning technologies affects students' cognitive functioning and psychological well-being. The result implies that students faced the techno-stress on a moderate level with an $M = 14.40$, cognitive fatigue with an $M = 13.83$, attention difficulty with an $M = 14.16$, and psychological effect with an $M = 14.84$. This shows that the digital learning materials exert high cognitive stress on students.

Techno-stress and cognitive fatigue correlated positively, $r = 0.648$, $p < 0.001$, attention difficulties and cognitive fatigue also correlated positively, $r = 0.561$, $p < 0.001$, and psychological effects and cognitive fatigue correlated positively, $r = 0.533$, $p < 0.001$. As students experience more technology stress and attentional challenges, they become more likely to experience mental fatigue and a drop in cognitive efficiency. The above findings are in line with cognitive load theory which states that an overload of external demands can exceed working memory which hampers learning.

Moreover, results from the regression (B techno-stress = 0.516, $p < 0.001$; B attention impairment = 0.248, $p = 0.005$) show that techno-stress was the strongest predictor of cognitive fatigue. The regression model overall explained 51.1% variance of cognitive fatigue ($R^2 = 0.511$). Thus, these factors contribute to students' cognitive fatigue significantly. Although psychological effects display a strong correlation with cognitive fatigue, it does not appear to be a significant predictor when controlling for other variables.

In conclusion, it is observed that prolonged engagement in Technology Intensive Learning Environments (TILE) provokes techno-stress, attention disruption, cognitive fatigue, and psychological distress among undergraduate students. As digital technologies take center stage in the world of higher education, a growing need is being felt on the part of the educators and the institutions to begin appreciating the cognitive limitations of the learners. These measures may develop learning effectiveness, support student preference, and contribute to more beneficiary educational experiences in a digital world.

Declarations

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Conflict of Interest: The authors declare no conflict of interest.

Ethics Approval: The study was reviewed by the Department Research Coordination Committee (DRCC), Department of Language, Culture and Society, SRM Institute of Science and Technology (SRMIST), Chengalpattu, Tamil Nadu, India, under Certificate/Reference No. SRMIST/LCS/DRCC/EEC/20260010, which is responsible for overseeing research ethics within the Department and functions in alignment with the institutional ethical review framework. Based on the nature of the study, involving only the collection of quantitative responses from participants and no personally identifiable or sensitive information, the study was considered exempt from formal ethical approval. The study was also conducted in accordance with the ethical principles of the Declaration of Helsinki.

Consent to Participate: Informed consent was obtained from all individual participants before data collection. Participants were informed about the purpose of the study, the voluntary nature of their participation, and their right to withdraw at any time without penalty. The informed consent documentation is available as a supporting document. No personally identifiable or sensitive data were collected. The study did not include participants under the age of 16.

Consent to Publish: Not applicable.

Data Availability: The data generated and analyzed during the current study are not publicly available but are available from the corresponding author upon reasonable request.

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Figures

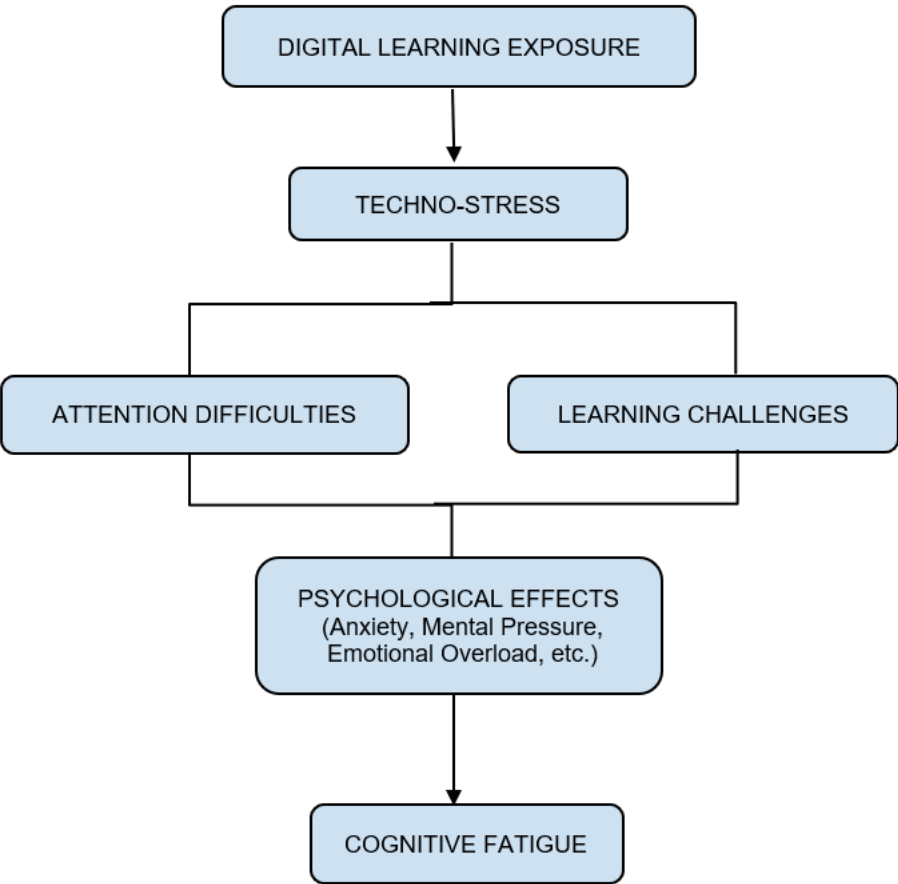


Figure 1
Conceptual Framework of Variables

Information Processing Model

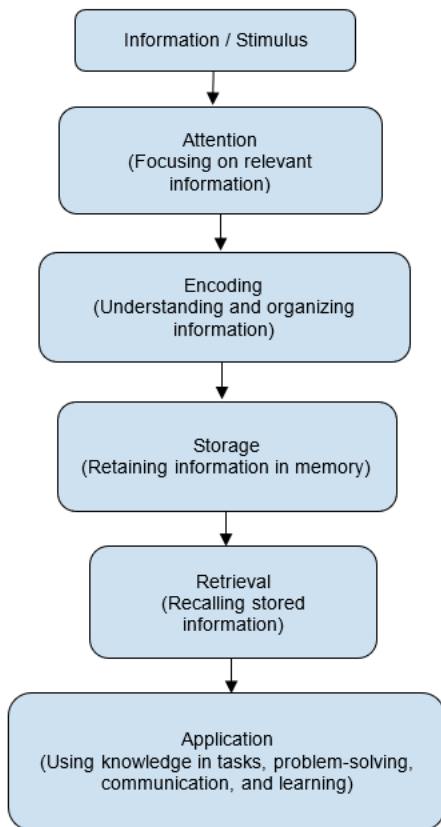


Figure 2

Cognitive Stages of the Learning Process

Psychological Impact Model

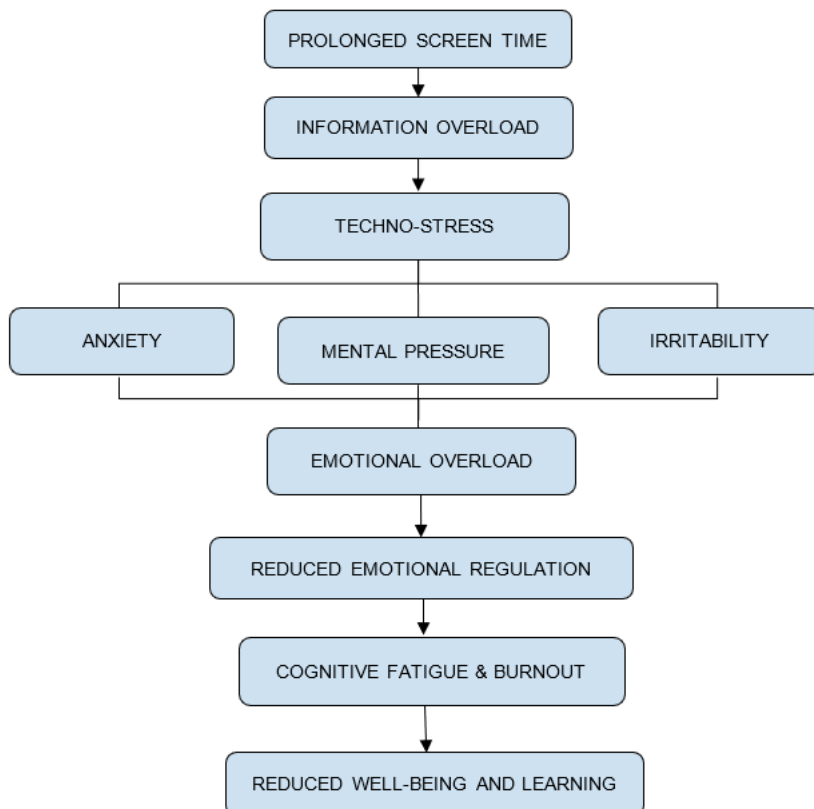


Figure 3

Psychological Effects of Prolonged Screen Time on Cognitive and Emotional well-being.