

The Double-Edged Sword of EdTech : Attention , Cognition and Engagement in the Digital Learning Environment

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Abstract:

The adoption of Edtech has increased during the black swan event and post this event the learning and education has revolutionized, which has not only sparked the opportunities but has also developed some concerns related to students' attention span, cognitive development and engagement. This study aims to explore how the screen-based learning, online gaming and digital interaction has influenced the memory retention, focus. The research uses Primary data collection through survey. The study targets the students and educators. The research applies quantitative methods such as Descriptive statistics, Correlation analysis, ANOVA, Sentiment Analysis to measure the relationship between Edtech exposure and cognitive performance. The analysis provides the deeper insight into the behavioural and psychological effects. The findings aim to offer the suggestion and insights for the Edtech Developers, Educators, Policymakers to improvise the digital learning tools to cater the students' mental health, to overcome the distraction and the cognitive overload.

Statement of Problem: Post COVID-19 pandemic there is growing reliance on EdTech platforms, which has reshaped the education offering flexibility but has also triggered concerns about student attention. Despite the widespread usage of EdTech there are fewer studies which are concerned with psychological effects on learner particularly in India. This study addresses this gap by analysis of how EdTech influences attention span, cognitive functioning, and student engagement in digital learning environment.

Introduction: The COVID-19 pandemic, widely regarded as black swan event (A concept developed by Nassim Nicholas Taleb in 2007) has brought a unprecedented shift in the global

education. There has been an increase in the usage of digital platforms and Edtech platforms for the purpose of educational learning. This rapid and unplanned transition gave rise to the explosive growth educational technology (Edtech) platforms such as Byju's, Unacademy, Vedantu, Coursera, Udemy which acted as the supplementary tools to the traditional learning (Dhawan,2020). While reliance on edtech for the learning has not only offered a new dimension to the education but has also led to a various challenge which are psychological and developmental challenges. Learners have a limited capacity to process the information, but with the overloading of the content on the edtech platforms and multitasking demands on the EdTech platforms can overwhelm the working memory, reduce the retention, and impair the comprehension. Excessive usage of multimedia, pop ups notification along with the various interactive chatbot makes it difficult to focus, absorb content or retain the information efficiently. Cognitive load theory by Lord Sweller propounded about the above-mentioned argument that the working memory has a limited capacity and when too much information is overloaded in the unfamiliar formats, it overloads the brain. Though Edtech also plays a significant role in the cognitive development such as quizzes, Gamified learning features and the interactive modules can stimulate the critical thinking and problem solving which can lead to improvement in the cognitive development These features encourage the active engagement which ultimately leads to memory retention and conceptual understanding. But the prolonged exposure to the screen-based learning environments has raised various concerns regarding the digital fatigue, reduction in the physical interactions, emotional detachment among the college students. With the blurring of the various boundaries, students are often gets caught up in the continuous loop of multitasking and the cognitive overload (Zheng et al, 2020) Few of the factors then underlines the need for in depth investigation into how the Edtech impacts students' psychological wellbeing and cognitive functions. The study aims to examine the relationship between the EdTech usage and students 'attention span, cognitive development, and engagement levels. Through a combination of the primary data collection the paper explores whether the digital learning truly improves the education system and cognitive development.

Historical View of Education and linkages to cognitive development

Vedic Period (1500 BCE)

The Ancient Education system in India traces back its origin to Vedic times, which dates around 1500 BCE. This Phase is the earliest and known as the phase of the formal education system

in India. The knowledge was transmitted through Shruti (Heard Texts) and Smriti (Memorizing), primarily the four Vedas (Altekar,1934). Education was imparted in Gurukuls, where the main aim was the holistic development of students, and significantly, women were excluded from the education system. Brahmavaadini's were the women who pursued knowledge throughout their lives (Basham,1954). Lopamudra, Gargi, and Maitreyi, who engaged in the composition of the hymn for Rigveda, engaged in metaphysical debates and an inquiry into immortality. Women were Rishika, which indicated that spiritual and philosophical education for women was possible and valued in the early Vedic culture, where the curriculum included Vedic chanting, grammar, dharma, and Nyaya (Altekar,1934). The Shruti and Smriti practices ultimately enhanced memory and cognitive retention amongst students.

Post Vedic Period (1000BCE-600 CE)

The Post Vedic period marked a significant and noticeable transition in the Ancient Indian Education System. The post Vedic period witnessed the establishment of philosophical, scientific, and linguistic education alongside the continuation of religious instruction (Thapar,2002). While Vedas remained central to the education system, medicine, arts, and logic were also introduced (Altekar, 1934). The six Vedangas formed the base of advanced learning, This Phase also saw the institutionalization of education, as education centres like Takshashila and Nalanda got established, where emphasis was on Grammar, Medicine, and Astronomy. During this Phase, the dialogue on various philosophies between Guru-Shishya encouraged the critical thinking process. The Brihadaranyaka Upanishad also mentions the dialogue between Yajnavalkya and Gargi, in which Gargi challenges Yajnavalkya with questions on metaphysics. Katha Upanishad mentions Nachiketa and Yama's dialogues.

The Mauryan Period and Gupta Period (322-185 BCE)

The Period marks for Indian Education System, increased involvement of state and the proliferation of institutional learning. The increased emphasis on education was essential during the reign of emperor Ashoka as it became an important part of governance and public welfare, particularly with the spread of Buddhism. Ashoka's support established several monastic learning centres, where moral and philosophical education was imparted alongside traditional knowledge (Thapar,2002). The intellectual contribution of scholars like Kautilya (Vishnugupt), author of Artha Shastra, further demonstrated the Mauryan emphasis on Economics, Statecraft, Public Administration, and Ethics. Nalanda and Vikram Shila became a global centre for learning. Intellectual debates were at the core of the teaching and learning which developed cognitive skills of students.

Medieval Period (600CE-1700 CE)

During this period, rote learning continued, and education was rigid and doctrinal, which fostered memory and reasoning skills. However, the scope of creativity was limited due to religious and textual rigidity. Therefore, this period was marked by more of religious and textual learning.

Colonial Period (1757-1947)

British policies introduced Western-style education and adopted an Anglicist approach. Anglicism in education was shown as a serum to cure the darkness, focusing on Reading, Writing, and Arithmetic. The Indigenous system was replaced, and the ruling power emphasized the clerical training of the population rather than creative thinking, as they needed people who could be asked to follow the rules. Therefore, there was a constraint on cognitive development logical skills, and analytical skills. British Period focused on the development of technical education, where Lord Curzon made a significant contribution to the introduction of professional courses such as medicine, agriculture, engineering, by these various initiatives, Britishers laid the foundation for today's curriculum and teacher-centric learning instead of dialogue form of learning which was persistence during the ancient time.

Post-Colonial Period (1947 – 2000)

This Period marked a significant transformation in India's educational scenario. Post-independence, prioritization was nation-building through inclusive and equitable education. The University Education Commission (1948) and the Kothari Commission (1964-1966) laid the foundation framework to democratize education, emphasizing "education for social and national development "(Kothari Commission, 1966). A major reform that was introduced consisted of a push towards technology integration, albeit minimal compared to the 21st Technology. Open access systems were introduced. Educational Television and computer literacy programs were launched; in this context, the post-colonial Period served as the transitional Phase where education shifted from rote-based learning to student-centred approaches.

Contemporary Times (2000-2025) This Phase saw the rise of EdTech platforms land various initiative by government such as SWAYAM, DIKSHA and e-Pathshala. A shift from teacher centric instruction to student centric and technology centric. Technology has revolutionized the access and education system.

Literature Review: The integration of EdTech into the learning environment has transformed the way students interact with content, educators, and peers. However, the transformation has led to many concerns with respect to psychological and cognitive implications, mainly in the context of the attention paradox — a concept where an abundance of information leads to a decrease in the attention span and retention capacity of learners (Wu & Clarke, 2019). The attention paradox was first broadly observed in some of the digital media studies, where participants experienced reduced attention spans due to overstimulation (Carr, 2010). Taleb (2007), in his Black Swan Theory, argued that rare, unpredictable events—like the COVID-19 pandemic—disrupt societal norms and catalyse permanent shifts. The pandemic in 2019 acted as a Black Swan event not only for the medical and financial aspects but also for education sector, Closure of Educational institution forced rapid and necessary EdTech adoption, which altered the traditional learning modalities (Dhawan, 2020). This sudden transition from Traditional to EdTech introduced cognitive and mental strain and increased screen time, contributing to stress level, mental health issues and digital fatigue and last but not the least engagement levels, which have been severely impacted as the attention span has reduced over the time (Bolaños & Arrieta, 2022). A study by Mayer (2009) emphasizes and quotes the Cognitive Load Theory, which explains how the excessive usage of multimedia learning features can ultimately lead to negative impact a learner's working memory, further leading to lower memory retention. The shift to online EdTech platforms often results in a divided attention span as switching between various applications due to multitasking and pop-up notifications distracts the students toward undesirable tasks (Junco, 2012). These distractions contribute to information processing which is slower and shallow, which dampens deep learning and cognitive development (Rosen et al., 2013). Student engagement, which is a central aspect of learning outcomes, is also under scrutiny. Fredricks et al. (2004) classified the engagement levels into behavioural, emotional, and cognitive domains. Since the proliferation of EdTech, maintenance of continuous engagement has become a major task due to the lack of physical presence and lesser personalized interaction on the part of students (Kahu, 2013). Though some of the platforms offer adaptive learning and gamification and various other engaging features to boost the engagement levels of the students and to increase the attention span of students (Baker et al., 2020), these mechanisms may not always address the deeper and grave psychological impacts, such as loss of motivation and social isolation. Several studies have shown contradictory findings regarding EdTech's benefits where, some have criticized these platforms, and some have shown them as opportunities. EdTech has personalized learning

and has offered flexibility (Means et al., 2013); The pandemic has furthered and intensified tension and stress levels; students are reporting higher stress levels, mental health issues, emotional overload, and a lack of motivation (Zhao et al., 2021). The role of social media usage, multitasking, and switching across platforms also has a significant impact on cognitive performance. Ophir et al. (2009) have found that heavy media multitaskers perform worse in task-switching and maintenance of attention span. In the EdTech environment, where students often switch and scroll between learning apps and entertainment platforms, sustained and prolonged attention becomes even harder to achieve (Uncapher & Wagner, 2018). Short reels have depleted cognitive capacity and fragment focus. Frequent exposure to fast-paced content may condition the brain for novelty, which reduces the ability to engage in deep, sustained academic tasks. Interactive teaching strategies are needed to counter the cognitive overload Haliti-Sylaj & Sadiku (2024). Recent research has also focused on the psychological well-being of students. Prolonged exposure to online learning correlates with eye strain, fatigue, and anxiety (Moore et al., 2021). These various aspects lead to lowering and dip in the academic performance and scores and in the overall mental health and logical analytical skills also faces decline. Thus, there is a growing consensus on the need to balance technology integration with human-centric pedagogy (Selwyn, 2016).

Research Gap: While the attention economy and digital distraction have been widely discussed (Carr, 2010, Wu & Clarke, 2019), very few studies directly explore how the attention paradox manifests in virtual learning environments, especially among college students. The impact of design choices on attention and engagement remains a major research gap.

Variables:

Variable	Description
Number of hours EdTech used	Independent Variable
Fatigue	Dependent Variable
Multitasking Potential	Dependent Variable
Focus Duration	Dependent Variable
Distraction	Dependent Variable
Duration of Break	Dependent Variable
Improvement in Memory	Dependent Variable
Features of EdTech	Independent Variable
Stress	Dependent Variable

Faced Isolation	Dependent Variable
Faced Sleep Issue	Dependent Variable

Objectives:

- 1) To analyse the influence of Edtech platform on students' cognitive development and attention span during digital learning
- 2) To examine the relationship between EdTech usage and levels of student engagement, focus duration and psychological wellbeing.

Hypotheses:

H1: There is a significant relationship between focus duration and student engagement in EdTech -based learning environment

H2: There is a significant relationship between prolonged exposure to Edtech platforms and cognitive fatigue, which impacts students 'cognitive development.

Research Methodology

The research conducts the quantitative approach to explore the attention paradox and the impact of the Edtech on the psychology of students with respect to cognitive development and engagement. The research primarily relies on the quantitative methods. The data is collected through a structured questionnaire using the google form. The questionnaire was filled by Undergraduate and post graduate students across the various academic institution of India. The Research paper adopts the convenience sampling where 50 students across different disciplines were studied.

Data Cleaning and Coding: Dataset was cleaned before analysis to ensure accuracy, reliability, and consistency in the results. Data cleaning was performed using Python (Pandas and NumPy libraries). All variables were checked for the appropriate data types. Categorical Variables were encoded into numerical values using the label encodes for the analysis.

Data Analysis: Descriptive statistics along with T- test and ANOVA for the significance of differences across the platforms and education levels and correlation analysis was done for various variables for the identification of relationship between the screen time, focus, psychological impact. Heatmaps and the Correlation matrix were generated for the visual representation of various trends. The tools used for the analysis – Python (Pandas, Matplotlib, Seaborn)

Discussion:

This study analyses the Edtech platform impact on the student 's engagement level and cognitive development, here is the discussion for the same

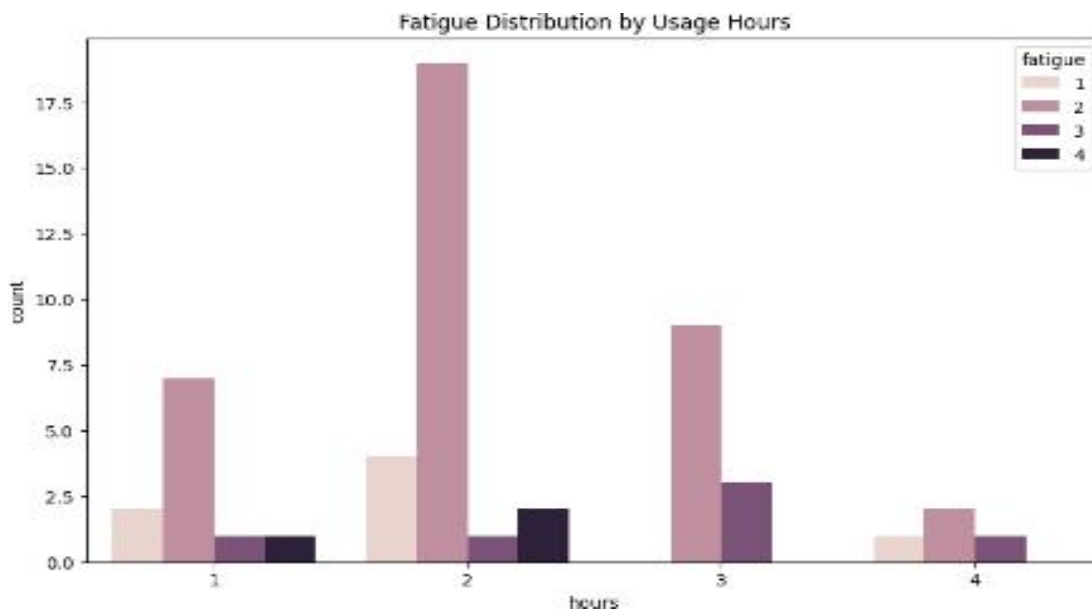


Figure 1: Author's compilation (On the basis of primary data), Where Never =1, Sometimes =2, Often =3, Always = 4)

In Response to the question: Do you experience digital Fatigue while using EdTech Platforms

Digital Fatigue often known as Technology Fatigue, the term "digital fatigue" encompasses various dimensions, including mental exhaustion, reduced productivity, and physical strain due to prolonged screen time and constant connectivity. It is a form of mental exhaustion which arises due to prolonged screen exposure. Digital fatigue is the general feeling of being overwhelmed by digital tools, associated with a drop in productivity and social well-being (Supriyadi et al., 2025). It is a feeling of being tired all the time, where scrolling all the time back and forth ultimately leads to reduced attention span and a drastic effect on the mental health. Upon analysis of responses of 50 participants, there are very few participants who never faced any sort of eye strain, mental strain due to prolonged usage of EdTech Platforms. The participants who use EdTech platforms for one hour have faced fatigue sometimes, those who used the EdTech platforms for two hours have faced fatigue sometimes, whereas the participants who have used the EdTech for 3 hours sometimes face fatigue. Therefore, it can be concluded that participants have faced fatigue sometimes.

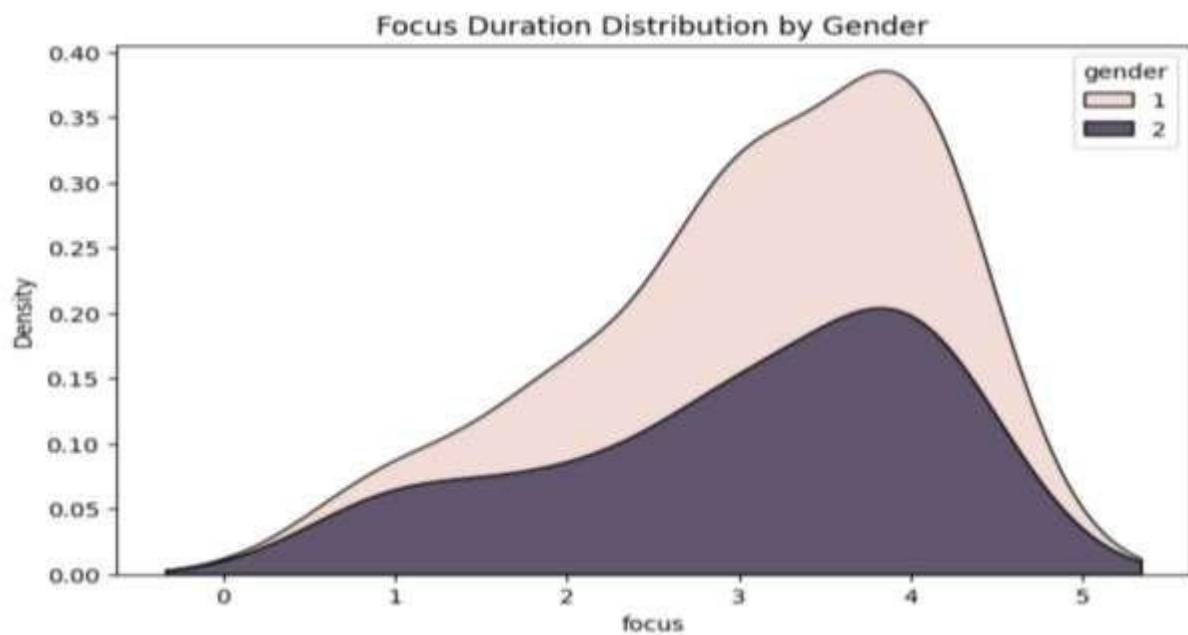


Figure 2: Author's compilation (On the basis of primary data), Female =1, Male =2

In Response to the question: How long can you stay focused while learning on EdTech Platforms

Digital Focus refers to the ability of an individual to maintain sustained attention and cognitive engagement during the digital interactions, especially in environments characterized by high level of multimedia stimuli and multitasking demands (Rosen et al. ,2011). It has been suggested that digital focus is negatively affected by media multitasking switching between various tasks and applications leads to increased cognitive load and information processing slows down (Ophir et al.). Analysis of the data collected reveals that females tend to concentrate on shorter focus session but with higher frequency (steeper peaks), whereas Males exhibit a broader range of focus duration with less clustering at shorter duration.

Females show a sharp peak in the focus duration around 0.5 units, with higher density (0.35) This suggests a tendency towards shorter but more frequent bursts of attention which means rapid task switching or micro learning sessions. Females fail to sustain deep focus which can actually hinder the deep cognitive processing despite high engagement. Whereas Males engage in moderately longer sessions. Most of the male persists longer, whereas some disengage quickly and have shorter attention span.

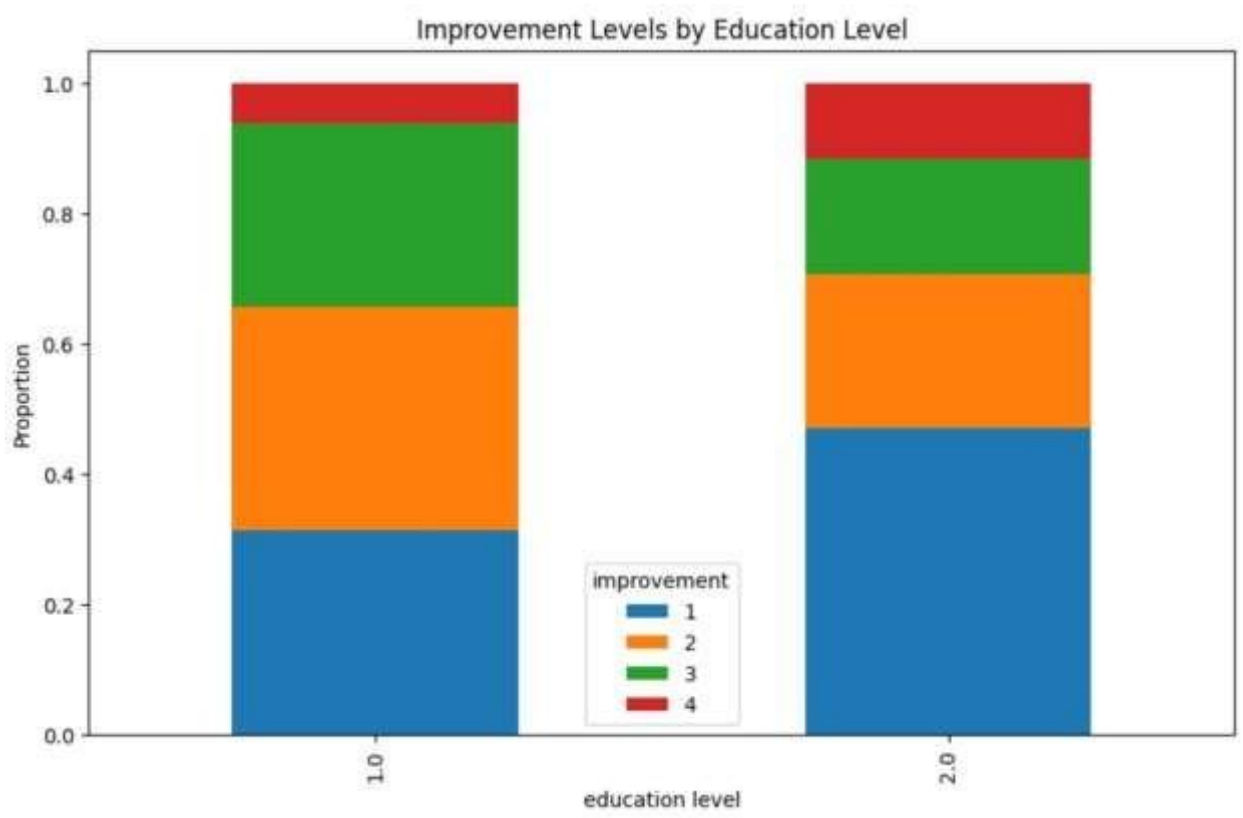


Figure 3: Author's compilation (On the basis of primary data), Significant Improvement=1, Some Improvement =2, No Change=3, Decrease in Retention =4)

On X- axis, 1.0 =Undergraduate, 2.0 = Postgraduate

In Response to the question: Have you noticed an improvement in the memory retention and comprehension using EdTech Tools?

Group Bar Chart visualizes the relation between improvement in memory retention due to Edtech Usage with respect to Undergraduate students and Postgraduate students. Upon analysis of data, it can be concluded that Postgraduate students have proportionately Significant improvements as compared to Undergraduate students when it comes to improvement in the memory retention. Undergraduate students have attained some improvement in the memory retention. Postgraduate students are fewer in proportion when it comes to experiencing no change in the memory retention and comprehension. The most important observation with respect to cognitive development is – Decrease in Retention level faced by students: Significant proportion of Post graduate students have faced retention drops as compared to Undergraduate students which owes to the various factors.

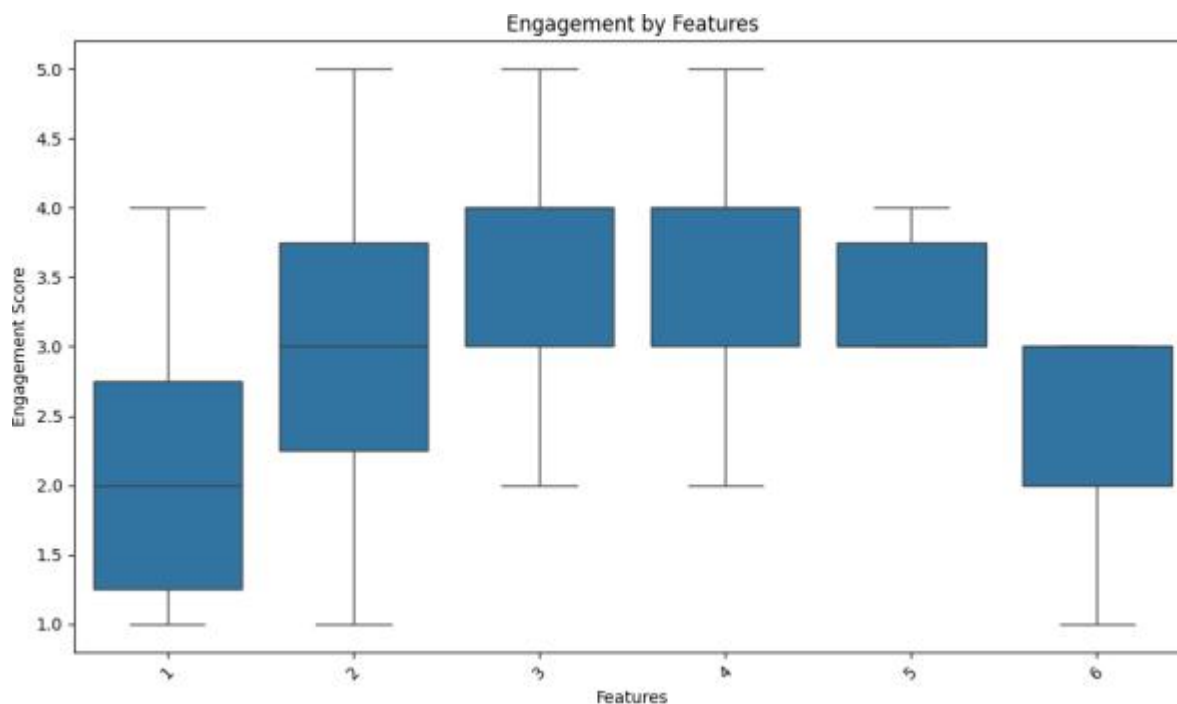


Figure 4: Author's compilation (On the basis of primary data)

On Y – axis, 1= Gamification, 2 = Interactive videos, 3= Live classes, 4= Ai powered personalized learning, 5=Peer discussion and forums, 6 = Others.

In Response to the question: Which feature of EdTech keep you engaged the most? * How Engaging do you find edtech based learning as compared to traditional learning.

The Box plot Showcases the Engagement level by Features, where Gamification interquartile range (IQR) is between 1.25 to 2.75 showcasing that almost 50 percent of participants lies between this interquartile range suggesting that this feature exhibit moderate engagement variability, which further suggests divergent user response. The feature of Interactive videos IQR lies between 2.25 to 3,75, whereas T whiskers of this feature are at 5, The bulk of engagement lies between these two points and Whisker at 5 suggests that this is a maximum engagement score. While IQR is narrower suggesting consistent engagement while accessing this feature but whisker at 5 suggests polarization. which reveals some users are extremely engaged. Live class IQR ranges between 3 to 4 suggesting live class has achieved most consistent and highest engagement, where narrower band suggests broad appeal of this feature. Same is the case with AI Powered Personalized Learning. Peer Discussion and forums IQR ranges between 3 to 3.75 and t whisker at 4, which exhibit consistently high engagement rivalling with the feature of Live classes in median scores. Other features are negatively skewed

while most features were positively and right skewed, IQR ranging between 2 to 3, with a long tail of disengaged users.

ANOVA: F statistics: 2.61, p – value = 0.0368

The ANOVA suggests that the between group variability is around 2.6 times larger than the within group variability. Whereas p value indicates a significant difference in the engagement scores among the groups Overall ANOVA showcases a statistically significant overall difference.

Group Difference (ANOVA): Education Level vs Engaging: F=0.13, p=0.7206 which suggests that education level does not have a significant effect on the student engagement in EdTech platforms Despite the education level difference engagement levels appears to be statistically similar.

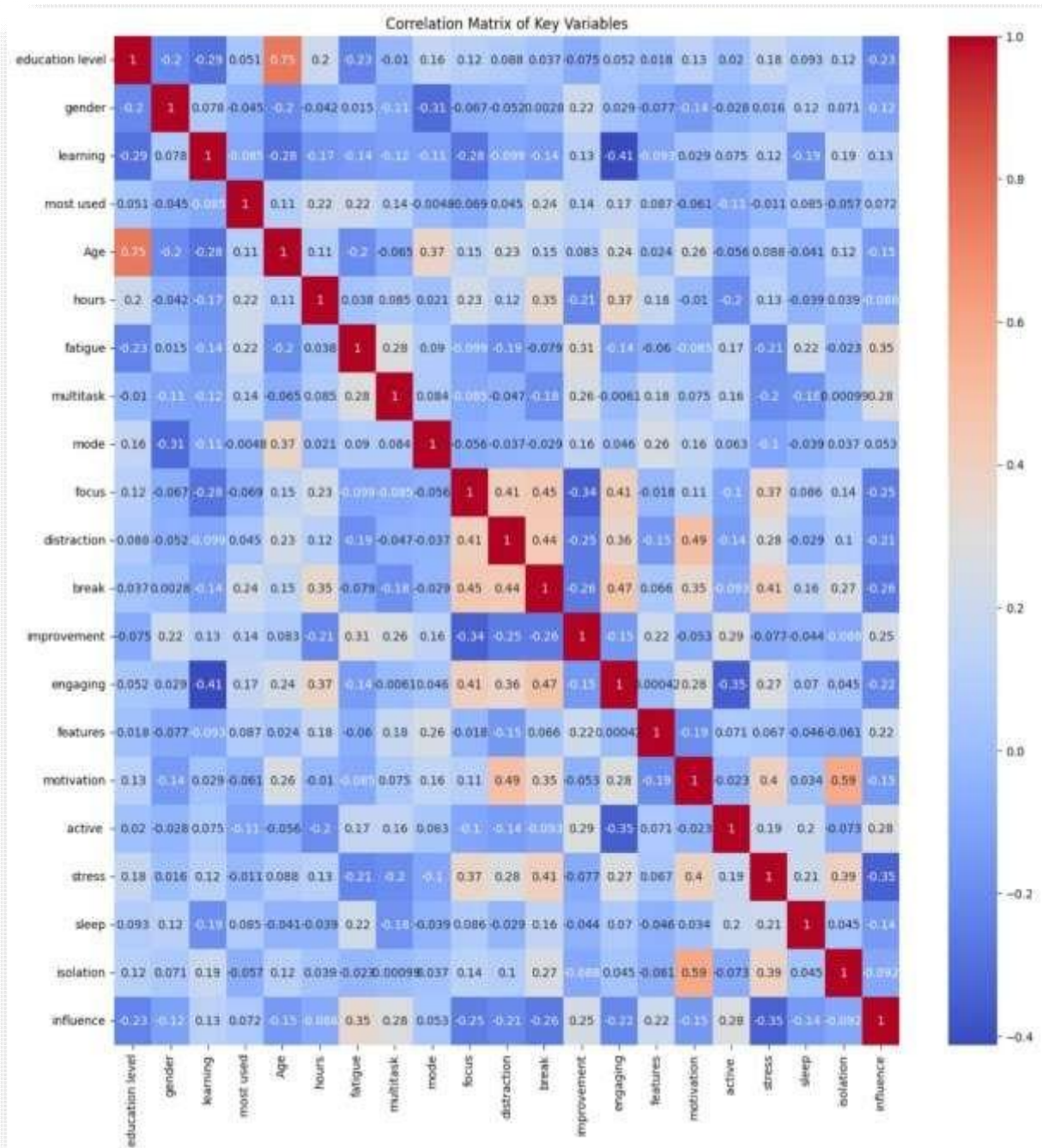


Figure 5: Correlation Analysis Heatmap of various variables

- 1) Feeling of Social Isolation due to EdTech Platforms and impact on Motivation have a moderate positive correlation.
- 2) Distraction due to EdTech Platforms and impact on Motivation have a moderate positive correlation.
- 3) Breaks taken during the Accessing of EdTech platforms and engagement on EdTech Platforms has a moderate positive correlation.
- 4) Fatigue due to EdTech and Positive influence on overall academic performance has a moderate positive correlation.
- 5) Break taken during the accessing of EdTech platforms and focus while learning on EdTech platform and Distraction while studying online as compared to offline learning have a moderate positive correlation.
- 6) Duration of Focus while learning on edtech platforms and intensity of engagement with respect to edtech based learning have moderate positive relation
- 7) Duration of Focus while learning on EdTech platforms and Stress level due to Online learning have a moderate positive correlation
- 8) Usage of Edtech Platforms for learning and engagement on EdTech Platforms have a negative moderate correlation.
- 9) Stress during the online learning and Social Isolation faced due to increased screen base learning reflects a moderate positive correlation.

Sentiment Analysis:

In this analysis opinions are mined and sentiments are categorized as positive, negative, and neutral. Main motive is to analyse emotional tone and opinions expressed in the text. This study checks the emotional tone of the users with the help of sentiment analysis and polarity distribution where the dataset is categorized in various sentiment categories .

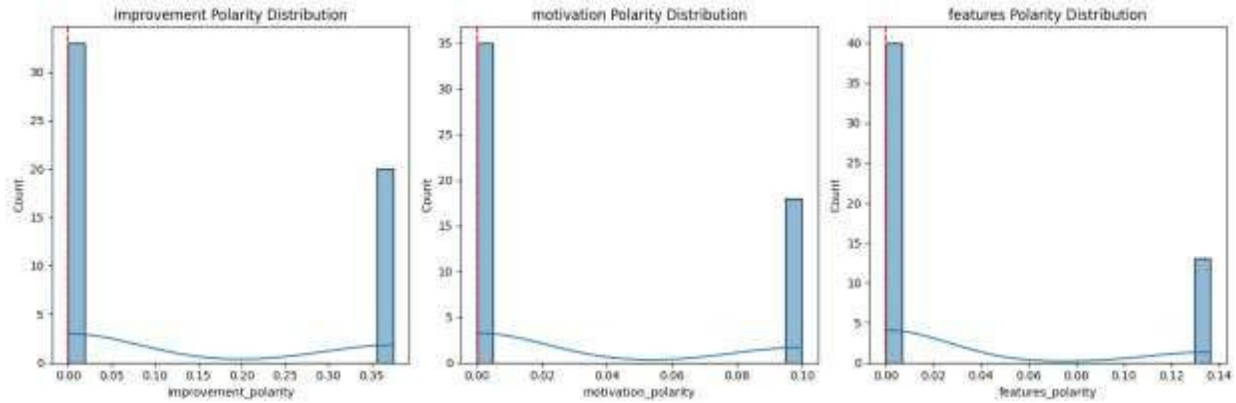


Figure 6: Author’s compilation (On the basis of primary data)

Sentiment analysis revealed strong positive polarity with respect to improvement in memory retention and comprehension while using the Edtech tools. Motivation lost due to distraction while studying online was milder. Feature Polarity distribution showcases lower proportions in polarity distribution. Most users feedback on improvement is moderately to strongly positive, implying users generally approve of changes or updates. Motivation factors are perceived as adequate but are not exceptional.

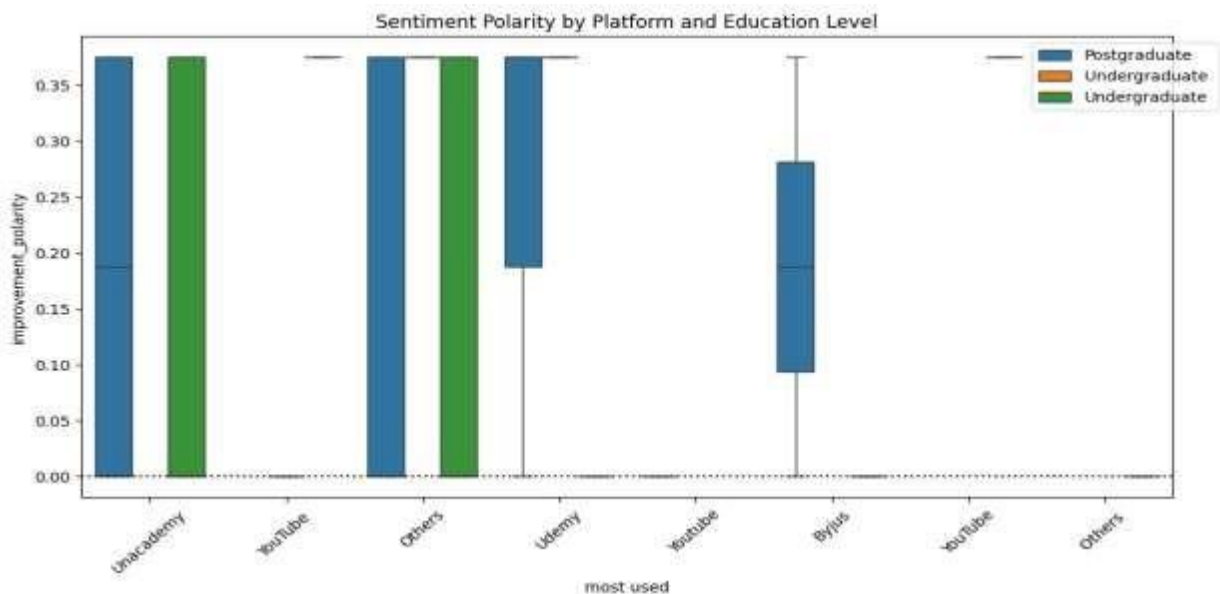


Figure 7: Author’s compilation (On the basis of primary data)

Sentiment Polarity by platforms and education level varied significantly. Postgraduate users rated Unacademy highest, while undergraduate rated YouTube as highest, others category consistently underperformed,

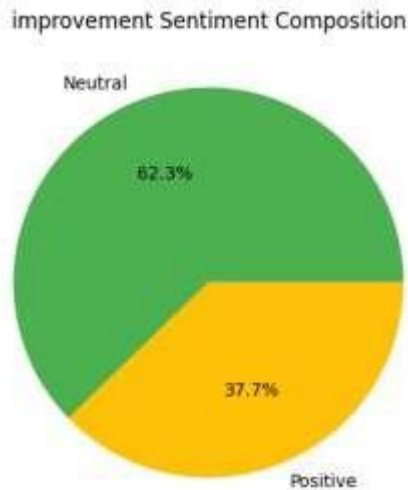


Figure 8: Author's compilation (On the basis of primary data)

Neutral sentiments dominate at 62.3 % of responses, Positive Sentiments accounts for 37.7%of responses with respect to improvement in memory retention and comprehension using EdTech tools.

Conclusion: This Research Paper dived into depth of Edtech and explore how the digital tools impact students, when in this fast-paced world, EdTech has become inseparable part of learning. which became as a medium of instruction during COVID-19 pandemic. The research was conducted. Findings show a mixed picture, there is clear support for the idea that EdTech boosts student engagement. Students are interacting more, staying involved and showing their interest due to the interactive features. Various EdTech Features, interactive tools and flexible schedule appears to contribute positively to keep students involved, therefore we accept H1, that there is a significant relationship between the usage of EdTech and students' engagement with statistical evidences. The second hypothesis -that there is a significant impact of EdTech on students' cognitive development was statistically rejected, though EdTech have supported engagement, its influence on the deeper cognitive processing and development remains limited.

This contrast reflects the essence of attention paradox; students seem more connected but that does not always translate into learning. There is a real need to rethink how EdTech is designed and used to bring improvisation in these EdTech Platforms.

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