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Digitalisation in Higher Education: A Systematic Review of its Impact on Health, Cognition, and Social Interaction

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Abstract. This systematic review investigates the effects of digitalisation in higher education on students' physical health, cognitive development, and social interaction by comparing traditional, blended, fully digital, and AI-enhanced learning models. A total of 164 peer-reviewed studies were selected using targeted keywords such as "AI in education", "digital learning fatigue", and "adaptive learning systems" and sourced from the databases such as Scopus, Web of Science, ERIC, and Google Scholar. The PRISMA framework guided the review process, with methodological quality assessed using the Mixed Methods Appraisal Tool and the

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Cochrane Risk of Bias Tool. Results reveal that fully digital models are linked to elevated digital fatigue (73.2%), increased stress (72%), and cognitive overload (48%), while blended approaches reduce these effects but still cause Zoom fatigue (62%). Traditional classroom settings support superior social interaction and sustained cognitive engagement, whereas AI-enhanced systems show potential for personalised instruction but risk fragmenting deep learning processes. Critically, this review underscores the need for robust state educational policies to regulate screen time, manage cognitive load, and ensure socially enriching digital learning environments. The findings offer essential guidance for educators, technologists, and policymakers aiming to balance innovation with student well-being and long-term academic success.

Keywords: cognitive development; digitalisation in education; state educational policy; social interaction; tertiary student health

1. Introduction

In recent years, the digital transformation of higher education has accelerated significantly, and this has been driven by the integration of online platforms, artificial intelligence (AI), and virtual collaboration technologies. These advances have led to the emergence of diverse instructional models—traditional classroom-based teaching, blended or hybrid formats, fully digital environments, and AI-enhanced systems—each offering unique combinations of accessibility, personalisation, and flexibility (Bates, 2019; Das et al., 2025; Rodríguez Bermeo et al., 2025). Although these innovations have expanded learning opportunities, they have also introduced complex challenges regarding students' physical health, mental well-being, cognitive workload, and social development (Keengwe, 2022; Made et al., 2025).

While there is a growing body of research evaluating the impact of digital learning technologies, much of this literature focuses narrowly on either the benefits or the drawbacks, often without a holistic view of how different learning formats compare (Jakoet-Salie & Ramalobe 2023; Komljenovic et al., 2024; Sanchez 2020). Additionally, the influence of national education policies on the implementation and quality of digital learning remains underexplored (Bobrytska et al., 2020). There is still limited evidence on how these varied models affect students across multiple dimensions—including fatigue and burnout, memory and attention span, and interpersonal communication—particularly in higher education settings where such outcomes are crucial to academic and professional success.

This review consolidated and compared existing research on four major types of learning environments—conventional face-to-face, blended, fully online, and AI-supported—to assess their respective effects on student health, cognitive performance, and social interaction. The review also considered how instructional design and digital integration levels contribute to these outcomes. Through this comprehensive synthesis, the study sought to provide evidence-based insights to guide educators, institutions, and policymakers in refining digital education practices to support both academic achievement and student well-being. To structure this inquiry, the following questions were addressed:

RQ1: How do traditional, blended, fully digital, and AI-enhanced learning models in higher education compare in regard to their impact on students' physical and mental health—specifically concerning digital fatigue, postural issues, stress, and burnout?
RQ2: In what ways do these four learning models influence students' cognitive performance, including memory retention, attention span, and critical thinking? Does AI-enhanced learning offer advantages in managing cognitive load when compared with traditional and other digital formats?
RQ3: How do traditional, blended, digital, and AI-driven learning environments affect students' opportunities for social interaction, communication, and collaboration? Do digital and AI-enhanced models adequately replicate the peer engagement fostered in conventional classrooms?

2. Literature Review

This literature review found that while digital education offers advantages in flexibility and accessibility, cognitive engagement through interactive technologies, collaboration across geographic boundaries via virtual classrooms and online discussion forums, scholars have debated its unintended effects on students' physical health, cognitive functions, and social engagement. Some research suggests that different digital learning models may vary in their impact on students, with blended and AI-enhanced models offering potential mitigations to the drawbacks of fully digital learning (Bates, 2019; Mulenga & Shilongo, 2024).

2.1 Health Impact of Digital Learning

Several studies indicate that prolonged screen exposure in fully digital learning environments is associated with eye strain, headaches, and cognitive fatigue (Devi & Singh, 2023). In contrast, blended learning models, which alternate between digital and face-to-face instruction, have been suggested to reduce screen-induced fatigue by incorporating offline learning moments (Tugtekin, 2023). However, other scholars argue that the effectiveness of blended models depends on course design and student self-regulation skills (Lepp et al., 2022). Moreover, the sedentary nature of digital learning has raised concerns regarding physical inactivity and posture-related health problems. Research suggests that students in fully digital and AI-enhanced environments tend to engage in fewer physical activities, thus increasing the risk of musculoskeletal discomfort (Goodyear et al., 2021). In contrast, traditional and blended models appear to provide more opportunities for movement due to in-person components, and this may contribute to better overall health outcomes (Bates, 2019). However, there is a lack of long-term studies comparing these risks across different learning models, indicating a need for further empirical research.

2.2 Cognitive Load and Memory Retention

Managing multiple digital platforms, AI-driven modules, and self-paced learning structures has been linked to cognitive overload, particularly in fully digital learning environments (Adigun et al., 2024; De Barros, 2024). Some researchers argue that AI-enhanced learning may alleviate this challenge by adapting to

student progress and personalising content, potentially improving cognitive processing (Kabudi et al., 2021). However, critics note that students may struggle with fragmented learning experiences in which AI personalisation leads to disjointed knowledge retention rather than deep learning (Xu, 2024). Research comparing traditional, blended, and digital learning models suggests that structured discussions and interactive face-to-face elements enhance memory retention (Zhang & Hou, 2024). In contrast, students in fully asynchronous online environments may face difficulties in knowledge retention and application, particularly when peer interaction is minimal (Mudd & Stewart, 2025). However, some studies propose that gamified and AI-driven adaptive learning may counteract this issue by boosting engagement and motivation, although the long-term retention effects remain inconclusive (Li et al., 2024).

2.3 Social Interaction and Communication Barriers

A significant concern in digital education is the lack of spontaneous peer interaction, which can affect student engagement and collaboration (Nozhovnik et al., 2023). Fully digital learning environments have been associated with lower levels of peer networking and student satisfaction than traditional or blended models (Wissing et al., 2022). Conversely, blended learning provides structured opportunities for both online and offline collaboration, potentially balancing the need for digital flexibility with social learning benefits (Bhadri & Patil, 2022). However, there is ongoing debate regarding the effectiveness of digital substitutes for traditional peer learning interactions such as AI-assisted discussion tools (Wang et al., 2024). Some researchers argue that students in fully digital learning settings may develop weaker verbal communication and interpersonal skills, potentially affecting their ability to engage in face-to-face professional or academic discourse (Mojtahedzadeh et al., 2024). However, AI-driven collaboration tools and virtual study groups attempt to replicate these interactions, but their effectiveness in fostering non-verbal communication skills remains contested (Akdilek et al., 2024). Further research is needed to assess whether fully digital and AI-enhanced learning environments adequately prepare students for real-world professional communication.

While digital learning has transformed higher education, research on its effects remains fragmented. Studies highlight both the benefits and drawbacks of different learning models, but there is no comprehensive comparison of how traditional (conventional), blended, fully digital, and AI-enhanced learning affect students' health, cognitive development, and social interaction (Bates, 2019; Garcia et al., 2025). Research on the health risks often focuses on screen fatigue and sedentary behaviour but lacks long-term data on their cumulative effects (Lepp et al., 2022; Tugtekin, 2023). Similarly, while fully digital learning is linked to cognitive overload, studies disagree on whether AI-driven models improve or hinder knowledge retention (Keengwe, 2022; Zhai et al., 2024). Additionally, there is limited research on how digital learning affects students' communication skills and peer interactions, particularly in AI-driven and fully online environments (Balalle, 2024; Michikyan et al., 2025). Given these gaps, there is a need for a systematic review that compares the long-term effects of different digital learning models on health, cognition, and social skills.

3. Methodology

This study followed a systematic review methodology, adhering to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Page et al., 2021), to synthesise the current evidence on how digitalisation in higher education affects students' health, cognitive development, and social interaction. The study employed a qualitative synthesis of empirical research, meta-analyses, and longitudinal studies published in peer-reviewed journals. This systematic review did not build upon or update any previous version. All the included studies were identified through new searches conducted across selected databases and registers, ensuring a comprehensive and up-to-date synthesis of the literature.

3.1 Search Strategy

A systematic literature search was conducted in Scopus, Web of Science, PubMed, IEEE Xplore, and Google Scholar together with selected grey literature sources. The search focused on peer-reviewed journal articles, conference proceedings, preprints, technical reports, and institutional white papers published between 2014 and 2025 to capture both established findings and emerging trends.

The following search terms and Boolean operators (AND/OR) were used to refine the search. Asterisks (*) were applied as wildcards to replace suffixes and capture variations of words, making the search broader and more inclusive. The search terms were *"digital learn" OR "online learn" OR "virtual educat*"** (to capture "digital learning", "digital learners", "online learning", "online learners", "virtual education", "virtual educational"); "digitalis*" AND "higher educat"** (to capture "digitalisation", "digitalization", "higher education", "higher educational"); "digital tool" AND "cognit* develop*"** (to capture "digital tools", "cognitive development", "cognitive developments"); "E-learn" AND ("mental health" OR "stress" OR "burnout")* (to capture "E-learning", "E-learners"); "virtual learn*"** AND ("social interact" OR "communicat* skill*")** (to capture "virtual learning", "virtual learners", "social interaction", "social interactions", "communication skills"); "AI in educat" AND ("personal" OR "learn* outcome*")** (to capture "AI in education", "personalisation", "personalization", "learning outcome", "learning outcomes"); "digital fatigue" AND "student well-being".*

To ensure comprehensive coverage, additional grey literature was reviewed from the following sources: (a) Conference proceedings—ACM Digital Library, IEEE Conference Papers, and Education Technology Conferences (e.g., EDUCAUSE, ICDE); (b) Preprints and white papers—arXiv, ResearchGate, and institutional repositories; (c) Government and policy reports—OECD, UNESCO, European Commission, and national education ministries; and (d) Industry reports and EdTech trends—Reports from EdTech companies. Additionally, backward and forward citation tracking were applied to identify additional relevant studies from the reference lists of key papers. Table 1 outlines the inclusion and exclusion criteria.

Table 1: Inclusion and exclusion criteria

Inclusion Criteria		**Exclusion Criteria**	
Study Type	Peer-reviewed empirical studies, systematic reviews, meta-analyses, and selected high-impact conference proceedings.	**Study Type**	Purely theoretical papers, editorials, opinion articles, and blog posts.
Population	Studies focusing on higher education students (undergraduate and postgraduate).	**Population**	Studies focusing on K-12 students or non-educational settings.
Publication Period	Studies published between 2014 and 2025 to ensure coverage of recent research.	**Relevance**	Research unrelated to digitalisation in higher education.
Language	Articles written in English.	**Quality & Peer Review**	Non-peer-reviewed conference papers and preprints without institutional credibility.
Grey Literature	Selected government reports, policy papers, and industry reports from reputable sources.		

Figure 1 provides a structured visualisation of the study selection process, following the PRISMA flowchart methodology and based on the template from Page et al. (2021) that was adopted and modified.

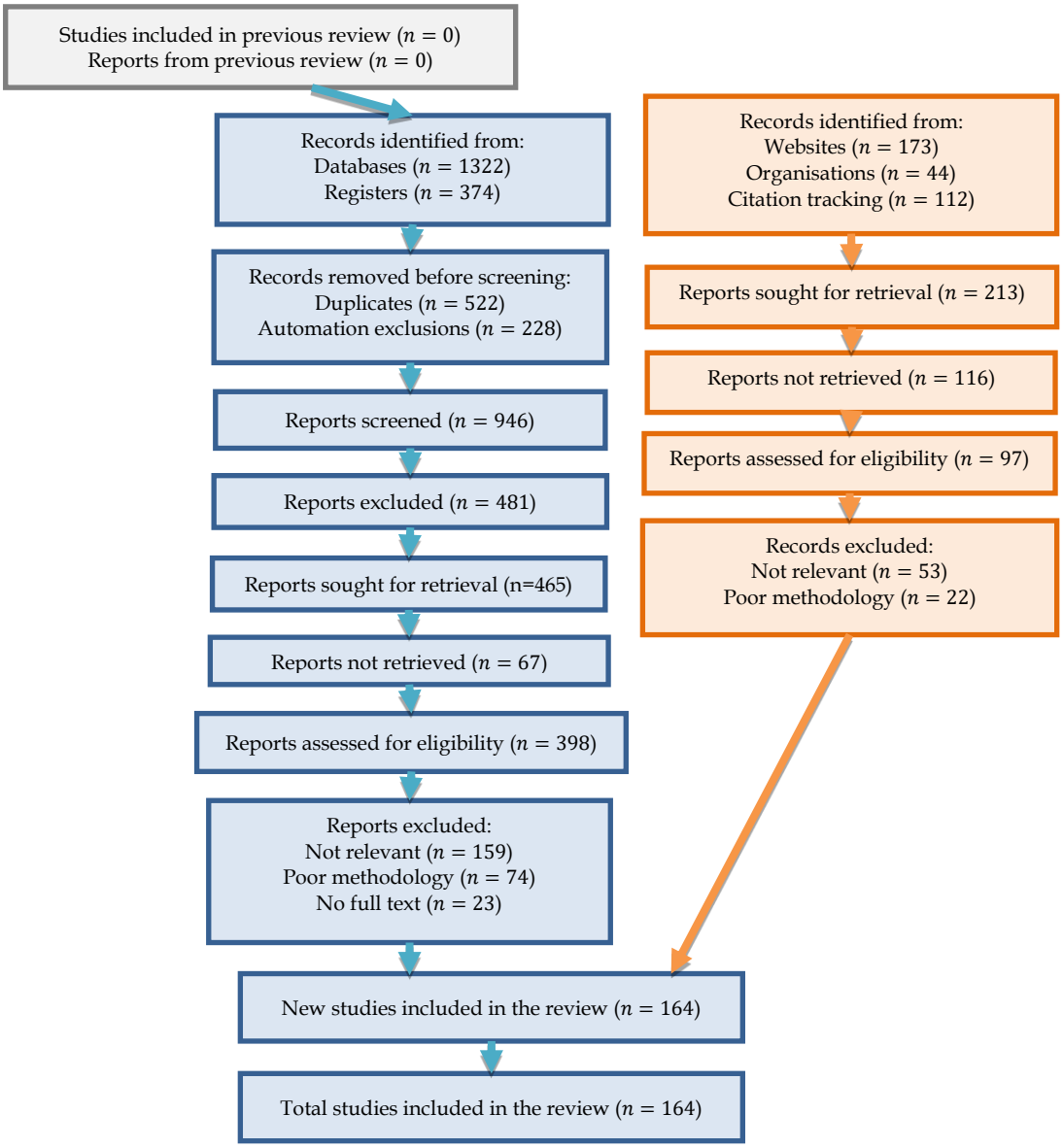

Figure 1: PRISMA-based study selection process
(Adapted from the template designed by Page et al., 2021)

3.2 Data Extraction and Synthesis

Following the selection of studies, a structured data extraction process was conducted to ensure consistency and reliability. Data were extracted using a standardised template, capturing key elements such as study details, research design, digital tools analysed, and thematic areas related to the study's focus. Study details included information on authors, year of publication, country, and publication source. The research design section documented the sample size and methodology, distinguishing between quantitative, qualitative, and mixed-methods approaches. The review also examined the types of digital tools that were analysed, including AI-driven learning systems, virtual platforms, online courses, and hybrid learning models.

The extracted data were further categorised into three primary impact areas: health, cognitive, and social interaction effects. The health impact category included studies addressing vision strain, posture issues, digital fatigue, stress levels, and mental health risks. The cognitive impact section assessed findings on memory retention, attention span, critical thinking, and problem-solving skills. The social interaction dimension explored changes in face-to-face communication, digital communication patterns, and challenges in group work dynamics. Additionally, studies were examined for key challenges and recommendations, focusing on barriers to effective digital learning, mitigation strategies, and institutional policies.

A narrative synthesis was performed to identify recurring themes, patterns, and research gaps across the selected studies. Where possible, a meta-analysis was conducted to assess statistical trends, provided that sufficient quantitative data were available to evaluate the impact of digitalisation on higher education students.

3.3 Quality Assessment

To ensure rigour, study quality was assessed using the Mixed Methods Appraisal Tool (MMAT) (Hong et al., 2018) for qualitative, quantitative, and mixed-methods studies and the Cochrane Risk of Bias Tool (RoB 2) (Sterne et al., 2019) for quantitative studies. Studies were evaluated based on methodological robustness, sample adequacy, validity of results, and risk of bias (selection bias, performance bias, reporting bias). Studies with a high risk of bias or poor methodological quality were excluded or discussed as limitations.

3.4 Ethical Considerations

This study did not involve human subjects or primary data collection and relied exclusively on secondary data from published research. As such, ethical approval was not required. All included studies were peer-reviewed or sourced from reputable grey literature databases, thus ensuring research integrity.

4. Results

A total of 164 studies were included in this systematic review. Based on the MMAT and the Cochrane Risk of Bias Tool, 86 studies (52.43%) were classified as high quality, 52 studies (31.70%) as moderate quality, and 26 studies (15.85%) as low quality. Common limitations among the reviewed studies included small sample sizes, reliance on self-reported data, and potential selection bias. The following sections present the key findings. These are organised according to the research questions and examine the impact of digitalisation on students' health, cognitive development, and social interaction.

4.1 Health Implications of Digital Learning Models

The review of existing studies confirms that prolonged exposure to digital technologies in higher education significantly affects students' physical and mental health. Research included in this review (Agarwal & Agarwal, 2022; Almutairi et al., 2024; Elsaid & Abdelwahab, 2024; Paulus et al., 2023; Seresirikachorn et al., 2022) highlight fully digital learning as a key contributor to digital fatigue, eye strain, postural discomfort, stress, and burnout. However, the

extent of these effects varies across different learning models, with traditional, blended, fully digital, and AI-enhanced approaches presenting distinct health outcomes. Table 2 summarises these findings and provides a comparative overview of how different digital learning models affect students' physical and mental well-being.

Table 2: Findings on the health impact of different learning models

Learning Model	Health Impacts Identified in Literature	Source
Fully Digital	High digital fatigue (73.2% report eye strain), cognitive overload (48% more often than hybrid learners), increased stress and burnout (72% experience higher anxiety levels), and posture issues (67% report development of neck/back pain due to prolonged screen time).	Almutairi et al., 2024; Elsaid & Abdelwahab, 2024; Paulus et al., 2023; Seresirikachorn et al., 2022
Blended	Moderate fatigue reduction (28% decrease in screen fatigue compared with fully digital), lower stress levels (35% less stress than fully online learners) but still subject to Zoom fatigue (62% experience virtual learning exhaustion).	Tugtekin, 2023; Lepp et al., 2022; Basch et al., 2025
Traditional	Least digital fatigue (minimal screen exposure), better posture and physical activity but lack flexibility and may induce stress due to rigid scheduling.	Alzahrani, 2022; De Bruijn-Smolders & Prinsen, 2024; Foo et al., 2021
AI-Enhanced	Potential for adaptive screen-time balance and personalised workload distribution but risks cognitive overload due to fragmented learning experiences. Lack of human interaction may contribute to stress.	Lepp et al., 2022; Rodríguez Bermeo et al., 2025; Wang et al., 2024

As shown in Table 2, fully digital learning environments are the most detrimental to students' physical and mental well-being, demonstrating high levels of digital fatigue, postural strain, stress, and cognitive overload. Research indicates that 73.2% of students in fully digital courses report eye strain and headaches, and they experience 40% higher screen-induced fatigue than those in blended settings (Almutairi et al., 2024; Paulus et al., 2023). This is likely due to prolonged screen exposure and a lack of structured offline engagement, which disrupts students' ability to regulate screen time effectively. In contrast, blended learning reduces digital fatigue by 28%, as it integrates both in-person and digital activities, allowing for more balanced screen usage (Tugtekin, 2023). However, Zoom fatigue remains an issue, with 62% of students still experiencing virtual learning exhaustion (Basch et al., 2025), suggesting that blended learning does not fully eliminate digital fatigue.

The postural health implications of digital learning further reinforce the risks of excessive screen time. Fully digital students are 2.3 times more likely to develop

chronic musculoskeletal pain than those in mixed-learning models (Almutairi et al., 2024). The high incidence of neck and back pain (67%) among online learners (Seresirikachorn et al., 2022) reflects the lack of ergonomic considerations in prolonged digital engagement. Traditional learning, by contrast, minimises posture-related health risks due to its emphasis on physical classroom movement and face-to-face activities (Alzahrani, 2022; Foo et al., 2021). Blended learning provides some ergonomic benefits by enabling students to alternate between digital and in-person sessions, but its effectiveness depends on course structure and individual adherence to ergonomic best practices (Bates, 2019). Although AI-enhanced models attempt to address these issues with movement reminders and adaptive scheduling tools, inconsistencies in implementation limit their effectiveness (Rodríguez Bermeo et al., 2025; Wang et al., 2024).

The findings in Table 2 also confirm that fully digital learning is associated with elevated stress, anxiety, and burnout, with 72% of students reporting increased anxiety following a shift to fully online education (Elsaid & Abdelwahab, 2024). The lack of face-to-face interaction and limited peer engagement contribute to social isolation and heightened stress levels. While traditional learning fosters stronger social connections and reduces stress through direct academic support (Alzahrani, 2022; Foo et al., 2021), its rigid structure can create additional stress for students managing multiple responsibilities. Blended learning appears to provide the most effective balance, reducing stress by 35% through maintaining both structured engagement and digital flexibility (Lepp et al., 2022). Lastly, AI-enhanced learning presents a mixed outcome; its personalised content delivery may alleviate information overload yet the absence of human support may increase social isolation and anxiety (Rodríguez Bermeo et al., 2025; Wang et al., 2024).

Cognitive overload remains a key issue, particularly in fully digital environments where students process large volumes of digital content without structured breaks. Fully digital learners experience 48% more cognitive fatigue than those in hybrid or traditional learning settings (Paulus et al., 2023). This is due to continuous screen engagement and limited variation in instructional modes, which can diminish concentration and reduce deep learning opportunities. Traditional learning distributes cognitive effort more effectively, integrating interactive discussions, real-time feedback, and hands-on activities, supporting long-term knowledge retention and conceptual understanding (Alzahrani, 2022; Foo et al., 2021). However, although AI-enhanced learning models offer adaptive pacing and workload management, which may mitigate cognitive overload, research suggests that excessive algorithm-driven adjustments may lead to fragmented learning, making it harder for students to develop deep comprehension and meaningful learning connections (Rodríguez Bermeo et al., 2025; Wang et al., 2024).

Overall, the comparative findings in Table 2 underscore the trade-offs between digital accessibility and health implications across learning models. Fully digital learning poses the highest health risks, and although blended models offer a more balanced approach, they still display challenges such as Zoom fatigue. Traditional learning remains the least harmful in terms of physical strain, but its lack of

flexibility can induce stress. Lastly, AI-enhanced learning presents promising solutions for workload optimisation, yet its impact on mental health and cognition requires further refinement to ensure student's well-being is not compromised. These findings suggest that an optimal approach would involve integrating structured screen-time management, ergonomic guidelines, and hybrid learning strategies to mitigate health risks while maintaining the benefits of digital education.

4.2 Effects of Digitalisation on Cognitive Performance

The review highlights that digital learning models significantly affect memory retention, attention span, and critical thinking skills. Fully digital learning often results in lower memory retention, as self-directed study and passive content consumption lack real-world application and immediate feedback. Alarifi and Song (2024) found that students in fully digital courses scored lower on delayed recall tests than students in blended or traditional settings. Blended learning improves retention by integrating structured discussions with digital resources, leading to higher retention rates (Akpen et al., 2024; Tugtekin, 2023). Traditional learning remains the most effective, with students in lecture-based courses retaining more information over three months than those in digital settings (Arden et al., 2024; Brown & Duguid, 2017). Regarding AI-enhanced learning, this model offers adaptive study plans that may improve short-term retention, although Jia and Tu (2024) suggest that fragmented content delivery may hinder deeper conceptual understanding. Digital learning models also affect attention span and cognitive load. Fully digital learning environments often lead to shorter attention spans due to screen distractions and multitasking. Toti et al. (2025) found that students in fully digital courses experienced 47% more attention lapses than those in blended settings. Blended learning helps regulate cognitive load by alternating self-paced digital content with in-person discussions, reducing attention lapses by 30% (Tugtekin, 2023). As discussed in Wang (2022), traditional classroom settings provide stronger support for sustained attention than fully digital learning environments in which engagement tends to decline more rapidly due to screen distractions and passive learning formats. Although AI-driven platforms attempt to optimise cognitive load through personalised difficulty adjustments, excessive algorithm-driven adaptation may lead to cognitive fatigue (Rodríguez Bermeo et al., 2025).

Critical thinking and problem-solving skills vary across learning models. Fully digital learning often limits analytical thinking due to reliance on automated assessments, thus reducing student engagement in deep discussions. Studies indicate that students in fully digital courses are less likely to engage in interactive problem-solving activities than those in mixed-learning environments (Balalle, 2024). In contrast, blended learning enhances critical thinking by facilitating structured peer discussions, leading to stronger problem-solving skills (Bhadri & Patil, 2022; De Bruijn-Smolders & Prinsen, 2024). Traditional learning remains the most effective for higher-order thinking, as face-to-face discussions and real-time feedback promote conceptual understanding and critical reasoning (Alzahrani, 2022). Whereas AI-enhanced learning introduces adaptive exercises, it lacks the human reasoning component that is essential for complex decision-making, thus

making it less effective for fostering deep problem-solving skills. These findings suggest that blended and traditional learning models provide stronger cognitive benefits, while fully digital and AI-enhanced models require better integration of interactive learning strategies to optimise cognitive engagement.

4.3 Influence of Learning Models on Peer Communication and Social Development

The review highlights that different digital learning models significantly affect student communication, peer interaction, and collaborative learning experiences. Fully digital learning environments often lead to reduced interpersonal engagement, as students rely on asynchronous communication and automated assessments rather than real-time discussions. Alarifi and Song (2024) found that students in fully digital courses reported lower levels of peer engagement and collaboration than students in blended or traditional settings. The lack of in-person interactions limits opportunities for spontaneous discussions, potentially affecting students' ability to develop interpersonal communication skills.

Blended learning provides a balanced approach by integrating both online and face-to-face interactions, which helps foster meaningful peer engagement. Studies suggest that blended models enhance collaborative learning and social presence, as students engage in structured discussions alongside digital resources. De Bruijn-Smolders and Prinsen (2024) found that students in blended learning environments demonstrated stronger social connectivity than students in fully online courses. Similarly, Bhadri and Patil (2022) emphasise that blended learning fosters peer discussion and teamwork, making it an effective model for improving communication skills.

Traditional (conventional) learning remains the most effective for developing social interaction, as it encourages face-to-face engagement, group discussions, and real-time feedback. Research by Alzahrani (2022) highlights that traditional classrooms provide a natural setting for interpersonal skill development in which students benefit from non-verbal cues, direct participation, and active listening. In contrast, AI-enhanced learning platforms introduce personalised feedback and adaptive discussion tools but they lack human-driven interaction, which is critical for fostering advanced communication abilities. These findings suggest that blended and traditional learning models provide stronger social engagement and communication benefits, whereas fully digital and AI-enhanced models require further refinements to integrate interactive and collaborative learning strategies better.

4.4 Comparative Overview of Learning Models

A synthesis of the findings from the reviewed studies revealed distinct patterns in how traditional, blended, fully digital, and AI-enhanced learning environments affect students' health, cognitive performance, and social engagement. Each model presents specific strengths and limitations. Traditional classroom settings consistently support strong interpersonal communication, deep conceptual learning, and minimal digital fatigue. Blended learning strikes a middle ground, combining digital convenience with structured face-to-face interaction to enhance

peer collaboration and sustain attention, although moderate screen fatigue remains a concern. Fully digital environments, while highly accessible, are more frequently associated with digital fatigue, fragmented attention, and reduced opportunities for spontaneous communication. Conversely, AI-enhanced learning platforms show promise in delivering personalised instruction and managing cognitive load, but they still fall short in replicating the complexity and richness of authentic peer interaction.

Social outcomes in particular demonstrate clear distinctions across the models. Traditional formats enable strong peer collaboration, support the development of non-verbal and listening skills, and foster real-time dialogue—benefits that remain difficult to replicate digitally (Ghafar & Ali, 2023; Komljenovic et al., 2024; Maloney et al., 2023; Teoh et al., 2025). Blended learning environments, while somewhat less immersive, enhance community and peer accountability through structured hybrid interaction (De Bruijn-Smolders & Prinsen, 2024; Rodríguez Bermeo et al., 2025). In contrast, fully digital models often rely on asynchronous forums and automated assessments, which limit informal dialogue and weaken students' interpersonal communication skills (Alarifi & Song, 2024; Sanchez, 2020;). Lastly, AI-enhanced environments such as those supported by adaptive platforms or immersive games offer structured collaboration but largely facilitate transactional exchanges rather than deep dialogic engagement (Guo & Wen, 2023; Seow, 2023). These comparative patterns are summarised in Table 3.

Table 3: Comparative impact of learning models on health, cognition, and social interaction (2014–2025)

Learning Model	Health Impact	Cognitive Impact	Social Impact
Traditional	Minimal screen exposure, low risk of fatigue or burnout (Haleem et al., 2022)	High retention and deep conceptual understanding due to face-to-face scaffolding (Jakoet-Salie & Ramalobe 2023)	Strong peer collaboration and real-time interaction; supports non-verbal cues, active listening, and the development of social confidence (Ghafar & Ali, 2023; Komljenovic et al., 2024; Teoh et al., 2025)
Blended	Moderate screen fatigue; some in-person activity buffers stress (Bobrytska et al., 2020; Yaqin et al., 2025)	Balanced memory and attention benefits from both formats (Huang & Wang, 2021)	Moderate-to-strong engagement through structured discussions and hybrid delivery; enhances peer accountability and fosters a sense of classroom community (Bhadri & Patil, 2022; De Bruijn-Smolders & Prinsen, 2024; Rodríguez Bermeo et al., 2025)

Learning Model	Health Impact	Cognitive Impact	Social Impact
Fully Digital	High digital fatigue, increased reports of stress and posture-related issues (Made et al., 2025)	High cognitive load, fragmented attention, lower retention (Haleem et al., 2022)	Weakened spontaneous communication and limited informal peer interaction due to asynchronous forums; reduced depth of collaboration and social presence (Alarifi & Song, 2024; Sanchez, 2020)
AI-Enhanced	Moderated fatigue with personalised pacing (Wei, 2023; Yuan & Liu, 2025)	Adaptive algorithms tailor tasks to learner needs but risk fragmented understanding (Yang, 2025)	Interaction scaffolded by AI-driven tools such as chatbots and adaptive prompts; supports structured collaboration but lacks the authenticity and complexity of human dialogue (Guo & Wen, 2023; Seow, 2023).

The comparative analysis underscores key trade-offs. Traditional learning remains the gold standard for fostering both cognitive depth and social connection but may lack adaptability. Blended models provide a viable alternative by integrating structured flexibility, albeit with moderate digital strain. Fully digital systems scale learning access but risk undermining engagement and collaboration. Meanwhile, AI-enhanced environments represent an evolving frontier—strong in customisation yet still in need of more robust, socially authentic interaction mechanisms.

5. Discussion

This systematic review evaluated how traditional, blended, fully digital, and AI-enhanced learning models affect student health, cognitive performance, and social interaction. The key findings illustrate that learning environments significantly shape students' well-being and academic outcomes and underscore a growing divergence between technological advancement and pedagogical adequacy. Notably, while digital and AI-driven platforms expand access and personalise instruction, they fall short in addressing holistic student development—particularly physical health and interpersonal communication. These conclusions resonate with prior reviews on the double-edged nature of digital learning (Jakoet-Salie & Ramalobe, 2023; Keengwe, 2022). However, this study expands the evidence by comparatively evaluating multiple models within the same framework.

5.1 Interpretation of Health-Related Findings

Fully digital learning environments consistently correlate with high rates of digital fatigue, postural strain, and elevated stress, findings echoed by Paulus et al. (2023) and Almutairi et al. (2024). Unlike earlier studies that focused on specific health symptoms, this review identified a pattern across digital formats: increased screen time without ergonomic or psychosocial safeguards leads to cumulative

physical and mental strain. In contrast, traditional learning offers the lowest physical health risks, while blended models mitigate some digital burdens through structured in-person sessions (Tugtekin, 2023). These findings suggest that hybridisation may serve as a compensatory strategy rather than a transitional format.

5.2 Cognitive Performance and Load Management Findings

Cognitive performance, load management in the context of memory retention, and critical thinking are best supported in traditional settings where active feedback, face-to-face dialogue, and low digital distraction foster deeper learning (Arden et al., 2024; Brown & Duguid, 2017). Supporting the findings of Akpen et al. (2024), the comparative advantage of blended learning lies in its ability to reinforce learning across modalities, showing improved long-term retention. Fully digital and AI-enhanced models, despite their adaptive features, show a tendency to fragment learning due to algorithm-driven pacing and lack of narrative continuity, a concern also raised by Jia and Tu (2024). Therefore, while AI promises individualised learning, it must be cautiously deployed to avoid cognitive overload and superficial engagement.

5.3 Social Interaction and Peer Engagement Findings

A significant disparity emerges in social outcomes. Traditional and blended learning strongly promote social cohesion and communication skills through direct interaction, consistent with the work of De Bruijn-Smolders and Prinsen (2024) and Alzahrani (2022). In contrast, fully digital platforms emphasise asynchronous tools and automated tasks, which limit spontaneous communication and peer bonding—findings substantiated by Alarifi and Song (2024). Furthermore, AI-enhanced tools such as chatbots or adaptive games offer structured interactions but fail to replicate the emotional nuance and unpredictability of human collaboration (Guo & Wen, 2023; Seow, 2023). Therefore, social skill acquisition in digital formats remains an unresolved challenge.

5.4 Comparative Synthesis and Policy Implications

When considered holistically, this review confirms and extends previous findings by demonstrating that no single model fully satisfies the demands of health, cognition, and communication. The trade-offs are evident. Traditional learning maximises cognitive depth and social engagement but lacks adaptability; fully digital formats enhance accessibility but risk impairing well-being and sustained attention; and AI-enhanced platforms offer customisation but struggle with human-centric learning outcomes. These findings imply that future state educational policies should prioritise hybrid frameworks that blend adaptability with in-person engagement alongside mandatory ergonomic and social learning guidelines.

5.5 Limitations and Directions for Future Research

This review is limited by its reliance on cross-sectional and self-reported data, which introduces bias and restricts causal inferences. It also underrepresents global variability, as most included studies originated from digitally advanced regions. Furthermore, longitudinal impacts and nuanced experiences with

emerging technologies (virtual reality classrooms) remain underexplored. Despite these constraints, the findings remain valid in mapping the current terrain of digital education. Future research should focus on (a) developing global datasets, (b) evaluating the longitudinal effects of digital models, and (c) refining AI systems to promote the emotional and social dimensions of learning.

Overall, the current review demonstrated that while digital and AI-based innovations present unprecedented opportunities, their effectiveness depends heavily on thoughtful integration with pedagogical and social design. Without this balance, technological advancement may widen, rather than bridge, gaps in holistic student development.

6. Conclusion

This systematic review contributes both theoretically and practically to the understanding of how digital learning models affect student health, cognition, and social development. Theoretically, the findings advance the discourse on digital pedagogy by framing learning models as multidimensional systems whose efficacy hinges on the balance between technological integration and human-centred design. The review reinforces cognitive load theory by demonstrating that excessive digital input, particularly in fully online formats, impairs attention and memory consolidation. The review also contributes to social learning theory, highlighting the irreplaceable value of face-to-face peer interaction in fostering communication skills and collaborative learning. Practically, the results provide actionable insights for educators, institutional leaders, and policymakers. They underscore the importance of designing learning environments that not only deliver content efficiently but also safeguard student well-being.

For practitioners, the review suggests adopting blended learning models that take advantage of the flexibility of digital tools without sacrificing social presence or cognitive clarity. For policymakers, the findings advocate evidence-based regulations concerning screen-time limits, ergonomic standards, and AI tool deployment to prevent health risks and ensure pedagogical integrity. Furthermore, AI-enhanced education should be developed with adaptive but structured pathways that mitigate cognitive fragmentation and support authentic interaction. Future research should explore the integration of immersive technologies such as virtual reality (VR) and augmented reality (AR) in hybrid models and examine cross-regional comparisons to evaluate digital equity. Longitudinal studies are particularly needed to assess how digital and AI-enhanced models influence learning trajectories, health outcomes, and professional skill development over time. By bridging pedagogical theory with an implementation strategy, this review offers a roadmap for more holistic, equitable, and sustainable digital education systems.

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Grammarly was used without any predefined prompts. ChatGPT was used with the following prompt:
Please check (proofread) and correct the language of this paragraph/text and improve its readability and clarity.

The suggestions generated by these tools were reviewed and selectively incorporated to refine the manuscript's language while ensuring that the original meaning and the academic integrity of the work were maintained. The use of these tools contributed to improving linguistic quality and reducing publication/proofreading costs.

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