

THE DIGITAL NATIVE BRAIN: A SYSTEMATIC REVIEW OF COGNITIVE, LEARNING, AND EDUCATIONAL IMPLICATIONS FOR GENERATION Z STUDENTS

Offor, Moses^{1*}, Ajakaiye Olusegun Abraham², Ali Yakubu³

Department of Educational Foundations, Prince Abubakar Audu University, Anyigba

*Corresponding Author

ABSTRACT

Background: The rapid diffusion of smartphones, social media, online platforms, digital learning environments, and other digital technologies has transformed the contexts in which Generation Z students learn, communicate, and access information. The label “digital native,” however, does not necessarily imply superior digital literacy or a biologically distinct cognitive architecture.

Objective: This systematic review synthesizes evidence on the cognitive, behavioural, social, and educational characteristics associated with Generation Z students’ engagement with digital environments and examines the extent to which the evidence supports the concept of the “digital native brain.”

Methods: The review was structured according to PRISMA 2020 principles. The manuscript reports searches across major education, psychology, health, and technology databases, including Scopus, Web of Science, ERIC, PubMed/MEDLINE, ScienceDirect, SpringerLink, and Google Scholar. Studies addressing digital technology use and cognition, learning, academic performance, digital literacy, or related educational outcomes were eligible. The current manuscript reports 124 records initially identified and 42 studies retained after screening and quality assessment.

Results: Evidence indicates that digital engagement is heterogeneous. Purposeful educational technology use can support access, collaboration, flexibility, engagement, and learning, whereas off-task use, problematic social-media engagement, and multitasking are more consistently associated with distraction and poorer academic outcomes. Technological familiarity does not automatically confer advanced digital literacy. Evidence concerning neurological change remains limited and does not establish a distinct “Gen Z brain.”

Conclusion: The digital native concept is better treated as a contextual framework for examining adaptation to digitally saturated environments than as evidence of inherent cognitive superiority. Educational practice should combine purposeful technology integration with digital literacy, sustained attention, critical reflection, and meaningful human interaction.

KEYWORDS: Generation Z; digital natives; digital technology; cognition; digital literacy; multitasking; learning; systematic review.

1. INTRODUCTION

The rapid diffusion of smartphones, social media, online platforms, digital learning environments, video content, and artificial intelligence has altered the contexts in which contemporary students communicate, learn, access information, and construct knowledge. Generation Z (Gen Z) has consequently become a central focus of educational, cognitive, and technology research. The term digital native was originally used to describe young people presumed to possess an intuitive familiarity with digital technologies, while the broader expression “digital native brain” has been used to discuss possible differences in attention, information processing, learning, memory, cognitive control, and social interaction associated with growing up in digitally saturated environments (Bennett et al., 2008; Bennett & Maton, 2010; Helsper & Eynon, 2010).

Despite the popularity of the digital-native concept, its strongest claims remain contested. Research has demonstrated substantial variation in technology access, frequency and purpose of use, digital competence, and educational experience. University students, for example, may rely heavily on a relatively narrow range of familiar technologies rather than the sophisticated knowledge-creation and collaborative tools sometimes attributed to digital natives (Margaryan et al., 2011). Similar heterogeneity has been documented among students in different national and

educational contexts (Thinyane, 2010; Thompson, 2013). Technological familiarity should therefore be distinguished from digital literacy, which includes the ability to locate, evaluate, create, communicate, and use digital information responsibly (Ng, 2012).

The cognitive consequences of digital engagement are likewise more complex than a simple beneficial-versus-harmful distinction. Digital technologies can facilitate information retrieval, collaboration, visualization, simulation, communication, personalized learning, and multimodal representation. Mobile learning has been associated with improved learning outcomes, although substantial heterogeneity exists across educational settings and interventions (Crompton & Burke, 2018; Garzón et al., 2025). Digital technology can also support deep learning when it is integrated with appropriate pedagogical processes (Wu, 2024). Conversely, off-task digital engagement and multitasking can compete with the attentional resources required for sustained academic learning (Sana et al., 2013; Uncapher et al., 2017).

Neuroscientific evidence requires particular caution. Research has examined associations between screen-based media use and developing cognitive-control and reward-related systems, but the evidence remains limited and does not establish that digital technology has produced a fundamentally different neurological architecture among Gen Z students (Bavelier et al., 2014; Marciano et al., 2021). Thus, the phrase “digital native brain” is most defensibly used as a conceptual shorthand for investigating how sustained interaction with digital environments may be associated with cognitive and learning processes, rather than as a claim of an inherently different brain.

Social media provides another important dimension of the digital environment. Meta-analytic and systematic-review evidence suggests that problematic or off-task social-media and smartphone use is often associated with poorer academic outcomes, while the direction and magnitude of associations vary by outcome, population, and type of engagement (Liu et al., 2017; Amez & Baert, 2020; Pyhältö et al., 2025). At the same time, broader reviews indicate that digital technology can have beneficial cognitive, social, and educational functions when content, context, interactivity, and purpose are appropriate (Anderson & Subrahmanyam, 2017; Odgers et al., 2022).

Against this background, the present review integrates evidence from educational technology, cognitive science, developmental research, and related fields. It focuses on attention, memory, executive functioning, multitasking, digital literacy, learning behaviour, academic performance, and technology-supported learning. The review also evaluates the assumption that Gen Z students constitute a cognitively distinct “digital native” generation and identifies implications for teaching and curriculum design.

2. CONCEPTUAL/THEORETICAL FRAMEWORK: THE DIGITAL NATIVE BRAIN

The conceptual framework titled “Understanding the Digital Native Brain” explains how continuous exposure to digital technologies may be associated with the cognitive, learning, and behavioural patterns observed among Generation Z students. The framework treats the digital environment as an important contextual input, encompassing ubiquitous technology access, continuous connectivity, multimedia content, multitasking demands, and online social interaction. These experiences are presented as factors that may shape how learners process information, communicate, and engage with learning.

Within the framework, the proposed digital-native characteristics include visual-spatial processing, rapid information processing, reward and motivation sensitivity, multitasking and parallel processing, neuroplasticity and adaptability, and preferences for interactive and immersive learning. These characteristics are linked to mediating cognitive and learning processes such as selective attention, information filtering, meaning making, problem solving, and continuous feedback. The framework then connects these processes with behavioural and learning outcomes, including agility in learning, creativity and innovation, collaboration, global awareness, self-directed learning, and future readiness.

The framework is used as a conceptual lens rather than as evidence that Generation Z possesses a biologically distinct brain. Contemporary evidence remains insufficient to establish a fundamentally different neurological architecture for Gen Z students; therefore, the “digital native brain” is interpreted here as a conceptual description of possible cognitive and behavioural adaptations associated with sustained engagement in digitally saturated environments.

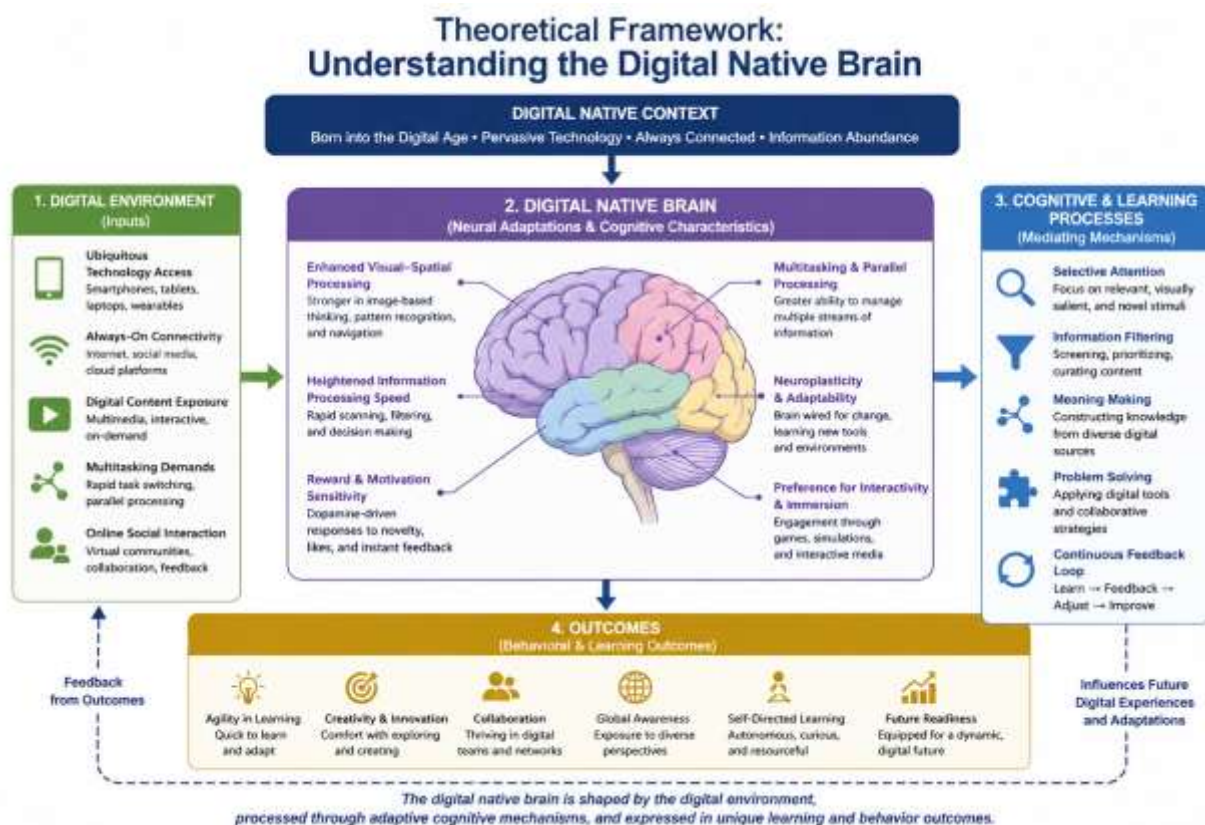


Figure 1: Conceptual framework of the digital native brain

3. REVIEW QUESTIONS

1. What cognitive characteristics of Generation Z students are associated with extensive engagement with digital technologies?
2. How does digital technology use relate to attention, memory, executive functioning, multitasking, and information processing?
3. What evidence exists regarding positive and negative educational consequences of digital technology use?
4. What factors moderate or shape the relationship between digital engagement and cognitive or learning outcomes?
5. To what extent does the available evidence support the concept of the “digital native brain”?

4. METHODOLOGY

4.1 Review Design and Reporting Framework

This study was structured as a systematic literature review and reported with reference to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 statement (Page et al., 2021). The review was designed to identify, evaluate, and synthesize empirical evidence concerning cognitive, behavioural, neurological, and educational characteristics associated with Generation Z students’ engagement with digital technologies. The review did not assume that Gen Z possesses a biologically distinct brain; instead, “digital native brain” was treated as a conceptual framework for examining patterns associated with digitally saturated learning environments.

4.2 Search Strategy

The manuscript reports searches of Scopus, Web of Science, ERIC, PubMed/MEDLINE, ScienceDirect, SpringerLink, and Google Scholar, supplemented by backward and forward citation searching. The search combined terms relating to Generation Z, digital technology, cognition, and education. A representative search structure was: (“Generation Z” OR “Gen Z” OR “digital natives” OR “digital native students”) AND (“digital technology” OR smartphone* OR “social media” OR “screen time” OR “mobile technology” OR “digital media” OR internet OR “online learning”) AND (brain OR cognition OR cognitive OR attention OR memory OR “executive function” OR

multitasking OR “information processing” OR learning OR “academic performance”). Search terms were adapted to the indexing requirements of individual databases.

4.3 Eligibility Criteria

Studies were eligible when they focused on Generation Z, adolescents, young adults, university students, or student populations substantially corresponding to the Gen Z cohort; examined digital technology, digital media, smartphones, social media, online or mobile learning, screen exposure, multitasking, or related environments; and reported outcomes relevant to cognition, learning, academic performance, attention, memory, executive functioning, information processing, digital literacy, learning behaviour, or educational engagement. Empirical quantitative, qualitative, mixed-methods, experimental, longitudinal, cross-sectional, and relevant review studies were considered. Eligible publications were peer-reviewed, available in English, and within the stated publication period.

Studies were excluded when they focused on populations substantially outside the review population, examined digital technology without a relevant cognitive or educational outcome, were opinion pieces or non-scholarly publications, lacked sufficient methodological information, or were duplicates. Because terminology surrounding Generation Z varies across studies, population eligibility was judged using reported age, educational level, birth cohort, or the authors' explicit classification.

4.4 Study Selection and Data Extraction

Records were screened by title and abstract and then assessed in full text against the eligibility criteria. The current manuscript reports 124 records initially identified and 42 studies retained after screening and quality assessment. These figures should be checked against the authors' reference-manager/export records before submission, because the source document contains other draft versions with different screening totals. Extracted information included author and year, country, design, sample characteristics, sample size, participant age or educational level, technology examined, intensity or purpose of use, outcomes, measurement instruments, findings, and methodological limitations.

4.5 Quality Appraisal and Synthesis

Quality appraisal considered methodological appropriateness, sample adequacy, measurement validity and reliability, statistical analysis, control of potential confounding, clarity of findings, and—where applicable—randomisation, comparison groups, qualitative credibility, and analytical transparency. Because the included evidence was heterogeneous in population, technology, design, measures, and outcomes, narrative synthesis was used. Findings were organised around attention and cognitive control; memory and information processing; multitasking and cognitive load; executive functioning; digital literacy; learning and academic performance; and positive and negative educational consequences. Correlational evidence was not interpreted as establishing causality.

5. RESULTS

5.1 Study Characteristics

The reviewed literature spans cross-sectional surveys, experiments, longitudinal studies, qualitative and mixed-methods research, and systematic reviews or meta-analyses. Participants were predominantly adolescents, university students, and young adults corresponding to the review's Gen Z focus. Technologies examined included smartphones, social-media platforms, laptops, mobile-learning applications, online learning environments, video games, general internet use, and other screen-based media. This diversity indicates that “digital technology use” is not a homogeneous exposure and that educational, recreational, social, and multitasking uses should not be treated as interchangeable.

5.2 Attention and Cognitive Control

Evidence concerning attention suggests that simultaneous engagement with multiple digital media can be associated with reduced sustained attention and poorer comprehension. Experimental research found that laptop multitasking during classroom instruction reduced learning among multitaskers and nearby peers (Sana et al., 2013). Mobile-phone use during lectures has likewise been associated with reduced note-taking and poorer subsequent recall and test performance (Kuznekoff & Titsworth, 2013). Media-multitasking research further identifies associations with attentional control and other cognitive characteristics, although the direction of causality remains uncertain (Uncapher et al., 2017).

5.3 Memory and Information Processing

Digital environments offer rapid access to large quantities of information and support multimedia and interactive representations. However, frequent switching among digital sources may increase cognitive demands and interfere with processing and retention of academic material. Evidence concerning digital media therefore suggests that memory outcomes depend substantially on how technology is used. Meaningful retrieval, visualization, collaboration, and active learning may support learning, whereas unrelated concurrent activities can divide attention and reduce depth of processing.

5.4 Executive Functioning and Multitasking

Multitasking emerged as a recurrent theme. Students may move rapidly between academic tasks, messaging, social networking, entertainment, and information searching, but this behaviour should not automatically be interpreted as enhanced cognitive flexibility. Research indicates that complex cognitive tasks are generally performed through rapid task switching rather than truly simultaneous processing, and such switching can impose additional cognitive demands (Kirschner & De Bruyckere, 2017; Nass et al., 2009). The available neuroscientific evidence remains insufficient to conclude that digital exposure has created a distinct cognitive architecture among Gen Z students.

5.5 Digital Literacy and Information Evaluation

A consistent finding is the distinction between technological familiarity and digital literacy. Students may be highly experienced with smartphones, social-media platforms, and digital communication while requiring support in evaluating sources, conducting academic research, recognising unreliable information, and using digital tools responsibly. Digital literacy is multidimensional and includes technical, cognitive, communicative, evaluative, and ethical competencies (Ng, 2012). Research on Gen Z information practices also suggests that online information processing is socially situated rather than purely individual (Hassoun et al., 2023).

5.6 Learning and Academic Outcomes

The evidence on academic outcomes is mixed and strongly dependent on the purpose and context of use. Educationally oriented mobile and online learning can improve access, flexibility, engagement, and learning opportunities (Crompton & Burke, 2018; Ulum, 2021; Garzón et al., 2025). Meta-analytic evidence also indicates that digital technology can support deep learning when integrated appropriately with pedagogy (Wu, 2024). In contrast, recreational and off-task use of smartphones and social media is more consistently associated with poorer academic outcomes (Amez & Baert, 2020; Liu et al., 2017; Pyhältö et al., 2025).

5.7 Positive Cognitive and Educational Effects

Potential benefits include rapid information access, multimedia resources, collaboration, interactive simulations, flexible learning, and opportunities for self-directed study. Mobile learning has demonstrated positive learning effects across educational settings, although heterogeneity remains substantial (Garzón et al., 2025). Research on digital games also indicates associations with several cognitive abilities, including aspects of visual attention, spatial ability, memory, and cognitive control (Zhao et al., 2026). These findings reinforce the importance of distinguishing among digital activities rather than treating all screen exposure as equivalent.

5.8 Potentially Adverse Effects

Potentially adverse outcomes were more consistently associated with excessive, problematic, recreational, or off-task engagement. Reported concerns include distraction, fragmented attention, multitasking, academic disengagement, problematic social-media use, sleep-related difficulties, and poorer academic outcomes. Reviews of screen-based media and developing-brain research emphasise that effect sizes and directions vary across ages, technologies, and contexts, and that much of the evidence is correlational (Stiglic & Viner, 2019; Oswald et al., 2020; Marciano et al., 2021).

6. DISCUSSION

The central finding of this review is that the “digital native brain” is more appropriately understood as a conceptual description of adaptation to digitally saturated environments than as evidence of a biologically distinct Generation Z brain. The evidence does not support a simple claim that growing up with digital technologies automatically produces superior cognition. Instead, outcomes vary according to the technology involved, purpose of use, intensity and duration of engagement, educational design, individual differences, and social context.

First, purposeful technology use can support learning. Mobile learning, online learning, multimedia resources, collaboration, and interactive activities can expand access and flexibility and may enhance learning when pedagogically aligned with clear instructional goals. This finding is consistent with the distinction between technology as a tool within an instructional design and technology as an end in itself.

Second, off-task engagement and multitasking present more consistent concerns. The evidence from classroom experiments and systematic reviews suggests that simultaneous digital activities can interfere with comprehension and academic performance. Importantly, however, association should not be equated with causation. Individuals with pre-existing attentional or behavioural characteristics may also be more likely to engage in media multitasking, and many studies rely on cross-sectional designs.

Third, the digital-native label can obscure important inequalities in competence. Students may be highly proficient in entertainment or communication technologies but less proficient in information evaluation, academic research, cybersecurity, ethical use, and professional digital communication. Educational institutions should therefore avoid assuming that students acquire advanced digital literacy simply through exposure to technology.

Fourth, the evidence supports a human-centred rather than technology-centred approach to education. Digital tools should be selected because they serve identifiable learning purposes. Instruction should also preserve opportunities for sustained reading, analytical writing, reflective discussion, inquiry, problem solving, collaboration, and interpersonal interaction. Such an approach does not reject digital technology; rather, it places technology within a broader educational ecology.

7. EDUCATIONAL IMPLICATIONS

7.1 Digital literacy instruction: Digital literacy should be taught explicitly, including source evaluation, academic research, information verification, ethical technology use, cybersecurity awareness, and critical media literacy.

7.2 Purposeful technology integration: Educators should align digital tools with instructional objectives and avoid assuming that more technology necessarily produces better learning.

7.3 Attention and deep learning: Learning environments should include protected periods for sustained reading, analytical writing, discussion, inquiry, and problem solving, particularly where off-task digital activity may compete for attention.

7.4 Balanced learning environments: Blended approaches can combine the flexibility and accessibility of digital learning with face-to-face interaction, mentoring, collaboration, and social-emotional support.

7.5 Assessment and feedback: Digital assessment and immediate feedback can support engagement, but they should be complemented by tasks that require explanation, reflection, transfer, and independent reasoning.

8. CONCLUSION

Generation Z students are learning within digital environments characterised by pervasive connectivity, multimedia information, social platforms, and rapid access to digital resources. The evidence reviewed here indicates that digital engagement can support learning, access, collaboration, and flexibility, but that off-task, problematic, and multitasking-oriented use can be associated with distraction and poorer academic outcomes. Technological familiarity should not be equated with digital literacy, and current evidence does not justify the claim that Gen Z possesses a fundamentally different brain. The “digital native brain” is therefore better treated as a contextual framework for studying adaptation to digitally saturated environments. Educational systems should combine purposeful technology integration with explicit digital-literacy instruction, cognitive depth, critical reflection, emotional and social support, and meaningful human interaction.

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