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Review Article

A scoping review of contemporary frameworks, challenges, and future directions on educational technology for digital generations

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ABSTRACT

This study is a thorough scoping review that seeks to thoroughly delineate the existing frameworks, difficulties, and prospective trajectories of educational technology for digital generations. Utilizing the technique established by Arksey and O'Malley (2005), a systematic search was conducted for English-language studies published between 2016 and 2025 in the WoS and Scopus databases, resulting in the inclusion of 46 publications in the analysis. The results show that technology acceptance models (TAM and UTAUT) (19 studies) are the most common in the field of educational technology. These models were established during the X-Y generation period and do not fully reflect the realities of digital generations. Digital learning infrastructures (n = 29) and mobile-social learning ecosystems (n = 22) were recognized as the predominant technological categories. The study revealed that the digital divide has intensified since the epidemic (28% lack Internet access), shortcomings in teacher preparedness constitute the principal obstacle to technological integration, and adaptive learning methods exhibit moderate to substantial impact sizes. The results underscore the necessity for the formulation of novel theoretical frameworks that encapsulate the inherent technology interaction patterns of digital generations, pedagogy-oriented technology integration, and holistic digital equity initiatives.

Keywords: educational technology, digital generation, Gen Z, Gen alpha, scoping review

INTRODUCTION

The concept of "digital natives" coined by Prensky (2001) at the beginning of the 21st century defined the natural correlation between students born after 1980 and technology and initiated a paradigm shift in education. Nonetheless, this notion, denounced by Bennett et al. (2008) as a "academic moral panic," has been rigorously scrutinized by subsequent empirical investigations. Kirschner and De Bruyckere (2017) and Reid et al. (2023) have proven that being around technology does not immediately make you digitally literate, and that thinking that everyone can perform many things at once is wrong. However, the expectations of Generation Z (Gen Z) and Generation alpha (Gen alpha) regarding educational technologies show clear shifts toward personalized, interactive, and contextualized learning experiences (Chardonnens, 2025).

The rapidly evolving nature of the educational technology field (AECT, 2020) and the transformative impact of the COVID-19 pandemic on digital learning have highlighted the need for a comprehensive and up-to-date assessment in this area. While there are studies in the existing literature that evaluate the effectiveness of educational technologies for digital generations, the fact that most of these studies use theoretical frameworks (TAM and UTAUT) developed during the X and Y generations creates an important research gap. Additionally, multidimensional challenges such as cognitive overload issues highlighted by Vedechkina and Borgonovi (2021), digital attention deficit challenges mentioned by Martin et al.(2025), and the deepening of the digital divide post-pandemic as revealed by Golden et al. (2023) require a holistic perspective.

The present study seeks to systematically delineate the existing frameworks, difficulties, and prospective trajectories of educational technology for digital generations. This research employs a scoping review methodology to thoroughly examine the literature from 2016 to 2025, aiming to identify theoretical deficiencies in the field, underscore practical implementation issues, and offer evidence-based recommendations for subsequent research. The results of this study will assist researchers, educators, and policymakers in formulating educational technology solutions that effectively meet the authentic learning requirements of digital generations.

LITERATURE REVIEW

Digital Generations

Prensky's (2001) groundbreaking publication developed the notion of "digital natives," suggesting a significant generational split between students born after 1980–termed "native speakers" of digital technology–and older "digital immigrants" who assimilated to technology later in life. Prensky (2001) contended that digital natives have neurologically distinct brains, favor parallel processing and multitasking, and necessitate fundamentally different pedagogical strategies that prioritize speed, visuals, and interconnected learning environments. However, extensive empirical research has systematically dismantled these assumptions. Bennett et al. (2008) made a huge impression when they criticized the idea of "digital natives" as "an academic form of a 'moral panic'" without convincing evidence. Their investigation indicated that assertions regarding digital natives exemplified "misplaced technological and biological determinism" that overlooked human, cultural, and contextual disparities (Selwyn, 2009).

Empirical research has significantly moderated the idea that a unique digital generation with uniform learning demands exists. People have long believed that digital natives learn and think in ways that are very different from older generations. This has not always been the case. For example, just because someone is exposed to technology doesn't mean they are automatically better at multitasking or more digitally savvy. If you plan lessons based on these ideas, they might not match how learning really happens (Kirschner & De Bruyckere, 2017). The prevailing view in contemporary scholarship is that technology enhances learning for individuals of all ages when utilized intentionally, aligned with educational objectives, and reinforced by explicit training in critical and information literacy.

In K-12 settings, children are familiar with technology but still have trouble figuring out what information they find online. This has led to changes in the curriculum to focus on media and information literacy. A growing intervention literature shows that teaching lateral reading, in which learners leave a page to investigate sources and claims, measurably improves the credibility judgments of participants from elementary school through adulthood (McGrew, 2024). The general agreement is that being familiar with apps is not the same as being able to search, check, source, and dispute. This means that media literacy needs to be taught in a structured fashion over time, not just assumed that individuals will learn it on their own.

Many students in college expect learning settings that are dynamic and full of technology, and research supports carefully planned changes that focus on active participation. A significant meta-analysis indicates that flipped classrooms yield moderate beneficial benefits on performance across many disciplines and educational levels, contingent upon the meticulous coordination of out-of-class materials and in-class activities (Strelan et al., 2020). At the same time, universities often overestimate students' academic digital skills. Studies continue to document gaps between what faculty assume students can do digitally and what students can actually do in scholarly contexts, which strengthens the case for making digital literacy outcomes explicit, assessed, and scaffolded across curricula rather than assumed at entry (Coldwell-Neilson, 2019). Together, these findings argue for coupling active, technology-enabled pedagogy with targeted development of research, data, and platform literacies.

Because they grew up in a world full of technology, digital generation has certain ways of learning that are different from other generations. According to Chardonnens (2025), engaging digital natives requires active learning, metacognitive methods, and intentional artificial intelligence (AI) integration. Gen Z wants individualized, inclusive, and contextualized learning, therefore educators must adopt more dynamic, student-centered methods. They certainly like active learning methods better than the passive manner of learning that is frequent in traditional lectures (Szymkowiak et al., 2021). In fact, a survey found that only 12% of Gen Z students believed they learn best by listening to lectures (Huss, 2023). They prefer project-based learning, hands-on activities, and teaching techniques that connect abstract ideas to real-world problems and uses (Yalçın-İncik & İncik, 2022). This need for active participation is heightened by a complex social dynamic. They want to be able to learn on their own, yet working together is also very vital for building community and sharing information (Hammad, 2025). For this generation, getting feedback and being creative are two big reasons to do things. For example, Gen Z students expect feedback that is not only rapid but also useful and shows them exactly how to get better. They are used to getting instant feedback through social media and games (Stoltz et al., 2025). They also have a strong and constant desire for more creativity to be included in their lessons and activities. They regard technology and creativity as two parts of who they are and want to learn in ways that let them express themselves and come up with new ideas (Hammad, 2025).

Educational Technology

The academic and moral discipline of educational technology focuses on enhancing learning and performance through the creation, utilization, management, and evaluation of technological processes, resources, and learning environments (AECT, 2020). Because technology is growing so quickly and there is a great need for good digital learning tools, the world of educational technology has changed a lot in the last few years. Educational technology encompasses many digital tools, platforms, and methodologies that enhance teaching and learning (Wang et al., 2024a). As schools throughout the world grow adjusted to the digital age, it's crucial to understand all of the many types of educational technology so that they may be used well and prepared for the future.

Educational technology now spans a wide set of tools and practices. It includes learning management systems, content creation and curation tools, assessment platforms, communication and collaboration services, learning analytics services, and fast growing A applications. This landscape is shaped by adoption factors such as usefulness, ease of use, social influence, access, and anxiety about complexity. These factors are well documented in recent systematic work (Dron, 2021).

A helpful taxonomy organizes educational technology by purpose, pedagogy, and data use (Blundell et al., 2022). One axis is purpose. Tools support instruction, assessment, learner support, and institutional management (Yeung et al., 2021). The second axis is pedagogical function (Ahmed & Opoku, 2022). Here a simple lens is presentation, participation, and production. A third axis is depth of change in tasks and outcomes. The SAMR model is useful for this last axis. It distinguishes substitution, augmentation, modification, and redefinition. Reviews show that researchers use SAMR to label practices and to reason about when technology changes tasks rather than just digitizing them (Blundell et al., 2022).

A second set of categories focuses on activity and evidence. Learning analytics aggregates traces from platforms and helps educators act on patterns. Recent reviews show that most analytics studies capture observable behavior such as clicks and time on tasks. Fewer research focus on emotional or social engagement. This gap indicates the necessity of integrating platform data with qualitative evidence to enhance the understanding of learning (Phillips & Ozogul, 2020).

A has become a distinct stratum in the landscape. Reviews in higher education describe five common uses. These are assessment and feedback, prediction, assistants, intelligent tutoring, and learning management. These applications transcend the aforementioned taxonomy and provide concerns regarding transparency, prejudice, and educator capability (Cheng et al., 2020). Taxonomies that are peculiar to a certain field fit into this larger picture. For instance, social media for learning can be divided into many types based on what you want to do and what you do, such watching, sharing, and creating things together. These kinds of taxonomies assist teachers match materials to defined learning goals and assessment standards (Demir, 2024).

The effect of the educational technology on digital generation

Research shows that educational technology helps many learners. The positive effects are strong and steady for students who grew up with digital tools. Onjewu et al. (2024) studied 240 Gen Z students. They found that many other uses of technology have clear effects. Most of these effects are negative for learning. One exception is internet searching, which helps learning. The authors explain this with cognitive load ideas. They advise designers to limit extra tools and to use them with care. (Chardonnens, 2025) reviewed 121 peer reviewed studies. AI based formative assessment tools raised math performance by 25 percent. Training in metacognitive strategies also helped. Students who learned these strategies scored 25 percent higher on self-assessment tasks.

Results improve when technology follows clear pedagogy. A meta-analysis in 2024 found positive effects on deep learning (Wu, 2023). Effects were stronger when teachers guided use, used systematic designs, mixed online and in person work, and supported collaboration. Equity results were small but meaningful. Less advantaged students gained more when schools used computer assisted learning and behavioral supports, not only wider access (Di Pietro & Castaño Muñoz, 2025).

Adaptive systems show notable benefits. Wang et al. (2024b) reviewed 45 studies in 2024. AI enabled adaptive systems produced a moderate to large effect on cognitive outcomes with g equals 0.70. These systems tailor paths using student performance, preferences, and learning data (Alrawashdeh et al., 2024). Contrino et al. (2024) reported higher pass rates and better retention with adaptive platforms. Personalized feedback in these tools gives immediate responses. This helps students fix misconceptions and stay engaged (Strielkowski et al., 2024). Adaptive technology supports equity by serving diverse needs and narrowing gaps across socioeconomic groups (Opesemowo & Adekomaya, 2024). Many schools now use blended models that mix digital and traditional methods. These models increase access and flexibility (Strielkowski et al., 2024). Success is needed more than hardware. Teachers need new knowledge and new classroom practices (Moltudal et al., 2022).

Technology helps when matched with learner needs and sound pedagogy. Still, balance matters. Kus (2025) urges a focus on digital literacy and healthy limits. Too much or poor use can harm learning. The goal is clear. Use technology to build learning that is personal, engaging, and effective for the digital generation.

The challenges and limitations of educational technologies for digital generations

Educational technologies for Gen Z and Gen alpha bring really cognitive and behavioral challenges. These students are digital natives. Gen alpha shows an average attention span of 8 seconds. Millennials average 12 seconds (Vizcaya-Moreno & Perez-Canaveras, 2020). Notifications, social media, and frequent task switching reduce attention and performance. Design fixes alone are not enough without changes in classroom norms and student habits (Martin et al., 2025). This makes it hard to teach complex ideas on digital platforms. Constant exposure to fast changing media leads to cognitive overload. Students struggle to process information deeply and to reflect (Vedechkina & Borgonovi, 2021). There are growing concerns about excessive screen use and social emotional risks for the youngest learners (Höfrová et al., 2024). Neurological adaptation to constant digital input changes how students learn and remember. Instructional design and delivery must be adjusted.

The digital divide increases inequality for these generations. After the pandemic, remote and blended learning widened gaps in devices, bandwidth, and home support. Students in less advantaged families and schools with low digital readiness lost more learning (van de Werfhorst et al., 2022). About 28 percent of school age children lack internet access at home or at school. Another 22.8 percent have home access but cannot use digital resources in class (Pierce & Cleary, 2024). The problem is worse in developing countries and rural areas because of weak infrastructure, cost, and low digital skills (Assefa et al., 2024). Marginalized students often face unreliable internet, shared devices, and little technical support. These barriers reduce engagement and performance and can harm long term opportunities (Soomro et al., 2020).

Teacher readiness is another major issue. Many educators must build digital skills while managing the demands of technology rich classrooms (Rangel-Pérez et al., 2021). Generation X (Gen X), millennial teachers and digital students report worries about ethics, overreliance on technology, and the risk that a could weaken authentic learning (Sergeeva et al., 2025). Technology changes faster than professional development. Many teachers feel unprepared to use digital tools well or to respond to the needs of Gen Z and Gen alpha. Digital curricula often ignore diverse learning needs, including students with disabilities and those who need specialized support (Mhlongo et al., 2023). Schools need sustained investment in training, inclusive digital materials, and clear frameworks that balance innovation with proven teaching principles.

Governance and ethics also set limits. Students express strong privacy concerns about learning analytics and data sharing. Trust depends on transparency and real choice (Mutimukwe et al., 2022). Research on online proctoring shows negative effects on student experience and raises fairness and surveillance questions. Integrity tools can conflict with inclusion and wellbeing (Lee & Fanguy, 2022). Generational differences further complicate adoption. Gen Z students are often more positive about generative A than their Gen X and Millennial teachers. Educators show more concern about overreliance and ethics, which slows policy and course design (Chan & Lee, 2023). Evidence for Gen alpha is still limited. Integration should be careful and guided by evidence (Höfrová et al., 2024).

METHOD

This scoping review maps and synthesizes contemporary frameworks, documented challenges, and proposed future directions in educational technology for digital generations through a transparent and iterative process aligned with established guidance. We followed the foundational stages for scoping studies developed by Arksey and O'Malley (2005) and the subsequent refinements that emphasize team calibration of the question, purposeful study selection, and iterative data charting, as recommended by Levac et al. (2010). Methodological decisions and reporting were further guided by the Joanna Briggs Institute approach and its updated methodological advice, and we reported our procedures in line with the PRISMA ScR checklist (Tricco et al., 2018).

Data Collection Process

Scopus and WoS databases were used to collect data. The following search query was used for publications. English studies published between 2016 and 2025 were included. The search query is as follows: ((“educational technology” OR “e-learning” OR “instructional technology” OR “learning technology”) AND (“digital generation*” OR “digital native*” OR “net generation” OR “generation z” OR “millennials”)) AND ((framework* OR model* OR “best practice*”) OR (challeng* OR barrier* OR issue* OR limitation*) OR (“future direction*” OR trend* OR outlook* OR “future perspective*”)).

136 publications were obtained from Wos and 198 publications from Scopus. 43 duplicate publications were identified. Then, two researchers independently read the titles and abstracts of the publications and selected appropriate ones. The use of educational technology in the study and the fact that the study was conducted in relation to digital generations were the main criteria. Another criterion was that the study examined digital generations. A total of 131 publications that met these criteria were selected for full-text review. In the full-text review, studies that examined the digital generation, Gen Z or Gen alpha in their respective contexts were preferred. Systematic reviews and meta-analyses that did not include primary data were excluded from the scope. As a result of this criterion review, 46 studies were selected for data analysis.

Table 1. Used technologies for digital generations

Category	Codes	N
Digital learning infrastructures	Learning management systems, video conferencing, MOOCs, & cloud and file sharing	29
Mobile and social learning ecosystems	Mobile learning & social media and messaging	22
Immersive and smart environments	Metaverse and virtual reality, smart classroom hardware, clickers and response systems, & wearables and sensors	13
Computing and creation tools	Programming and making & digital authoring and productivity	10
Content and information resources	Web and video resources	9
Intelligent and data-driven tools	AI chatbots and LLMs, intelligent tutoring and feedback, assessment and integrity tech, & learning analytics	8
Interactive and gameful pedagogies	Gamification mechanics, digital game based learning and quizzes, & serious games and simulations	7

Data Analysis

In this scoping review study, the data analysis of the selected 46 studies was conducted using a systematic and multi-stage approach. The data analysis process was designed in accordance with Braun and Clarke's (2006) thematic analysis framework and Arksey and O'Malley's (2005) scoping review methodology.

Data extraction from the selected studies was performed using a predefined data extraction form. This form was structured to include study characteristics (author and year), technologies used, theoretical frameworks, variables, main findings, challenges encountered, and future recommendations. Two researchers independently conducted the data extraction process on the first 10 studies and continued calibration until coding consistency was achieved.

After the data extraction process was completed, an inductive coding approach was adopted. The data obtained from each study were categorized to form meaningful code groups. Throughout the coding process, similar concepts were grouped together to develop overarching themes.

Seven main categories emerged during the analysis process:

(1) technologies used,

(2) theoretical frameworks and models,

(3) variables used in the studies,

(4) study findings,

(5) challenges encountered,

(6) future recommendations, and

(7) process model.

Each category is further detailed with sub-themes.

In the technologies used category, seven sub-themes were identified: digital learning infrastructures, mobile and social learning ecosystems, immersive and intelligent environments, computing and creation tools, content and information resources, intelligent and data-driven tools, and interactive and gamified pedagogies.

The theoretical frameworks analysis is grouped into nine categories: technology acceptance and adoption, motivation and interaction, gamified learning, learning theories and pedagogies, competency and literacy frameworks, sociocultural and critical perspectives, human-technology interaction, assessment models, and generational structures (**Table 1**).

FINDINGS

Most studies rely on core infrastructures. Learning management systems and video platforms dominate the set. This is clear in many reports. For example, "online learning via Zoom, Tencent Meeting, and Tencent Classroom" is routine in language and engagement work (Wang et al., 2022). Canvas is a common anchor for course work and assessment flows (Marcus et al., 2022)

Table 2. Theories and framework used in the studies

Category	Code	Study IDs
Technology adoption and acceptance	TAM core, UTAUT family, TRA and TPB, IS success model, diffusion of innovations, & computer self-efficacy and security awareness	2, 26, 30, 20, 1, 29, 15, 13, 39, 4
Motivation and engagement	MUSIC model, ARCS V, flow and GameFlow, academic engagement and digital readiness, & self-regulated learning	12, 19, 20, 43
Gamified and game based learning	Game cycle and IPO loops & gamification effectiveness	3, 10
Learning theories and pedagogies	Constructivism and constructionism, active and self-paced learning, & andragogy and heutagogy	37, 25, 6, 40, 5, 25
Competence and literacy frameworks	TPACK and ICT competence, digital learning capacity, & information literacy standards	42, 11, 46, 38
Sociocultural and critical perspectives	Cultural interface design, critical pedagogy and third space, & Web 2 and collaboration	33, 15, 41, 21, 22
Human technology interaction and smart learning	Smart education interaction models	45, 27
Assessment and evaluation models	IPO and IPEOF evaluation & taxonomies for design	19, 3, 8
Generational constructs	Digital natives lens, skepticism and nuance, & attitude strength note	12, 18, 38, 16, 36, 17, 32

Mobile and social use is the second pillar. Smartphones and messaging are everywhere. "WhatsApp group as a learning medium" appears as a central practice during remote learning (Muchsini et al., 2021). Dedicated m learning studies confirm this reliance on the phone as the main channel (Efiloğlu Kurt, 2022).

Immersive and smart environments appear in a steady minority. Some designs push into metaverse and VR. "We created a virtual classroom in the metaverse" describes a full virtual class with a 3D platform and a simulation tool in parallel (Barry et al., 2016). Smart classrooms also feature interactive boards and sensor rich rooms (Wu, 2021). Clickers remain a practical in-class response tool in health education (Toothaker, 2018).

Intelligent and data-driven tools show two tracks. One is AI chat and tutoring. The other is integrity and analytics. "use of ChatGPT among Gen Z university students" now enters integrity and ethics debates (Acosta-Enriquez et al., 2024). Turnitin and proctoring appear often in LMS based settings (Marcus et al., 2022). Google Analytics and class dashboards extend monitoring and feedback loops (Napaporn et al., 2023).

Gameful methods are common but not dominant. Simple quiz games like Kahoot are widespread, while heavier simulations and prediction markets are specific to course aims. "badges points leaderboards" capture the most typical pattern in computing courses (Chong et al., 2024). A different form is the "prediction market" class activity for economics and business courses (Buckley et al., 2017).

Creation and authoring tools matter for project based learning. Scratch supports creative computing in schools (Sayavaranont et al., 2018). Office, multimedia, and coding platforms support production across disciplines (Beaudoin & Avanthey, 2022). Content sourcing from the open web is routine. Students and teachers draw on "YouTube … online video clips" and search engines as standard study resources (Barry et al., 2016).

Course infrastructure and mobile use form the baseline. Investment in LMS integration with mobile access will likely yield the widest impact. Gameful and immersive tools work best when aligned to the skill target. Simulations and serious games fit design, policy, or systems courses. AI tools and analytics require clear policies on ethics and privacy. Creation tools should be scaffolded with rubrics and exemplars. Finally, open web content use should come with media literacy tasks and citation practice.

Technology adoption models dominate (**Table 2**). Many studies lean on TAM and UTAUT to explain intention and use. For example, "the technology acceptance model has been widely used to explain technology acceptance among students in various educational contexts" (Acosta-Enriquez et al., 2024). UTAUT is framed as widely applied for adoption and usage (Meet et al., 2022). TPB and TRA appear where intention and control are central (Muchsini et al., 2021). System success is often linked to information quality system quality and service quality from the D and M model (Abu Seman et al., 2018).

Motivation and engagement frameworks are the second pillar. The MUSIC model targets empowerment usefulness success interest and caring in digital tasks (Cuevas-Ortuño & Zavala, 2024). ARCS V and flow or GameFlow add design levers for attention challenge and feedback in serious games (Abd El-Sattar, 2023).

Table 3. Variables used in the studies

Category		Study count	Study IDs
Acceptance and adoption	Perceived usefulness, perceived ease of use, behavioral intention to use, actual use, attitude toward use, social influence, facilitating conditions, effort expectancy, performance expectancy, hedonic motivation, price value, habit, compatibility, cognitive absorption, accessibility, quality factors, & privacy and security	19	2, 28, 13, 4, 43, 26, 24, 29, 20, 1, 32, 22, 21, 17, 44, 27, 5, 39, 14
Learner characteristics	Personality, learning style, academic record, self-efficacy, enjoyment, digital nativity, & language and access	11	2, 28, 4, 43, 24, 8, 11, 20, 17, 38, 14
Pedagogical design	Gamification techniques, active learning, hybrid or blended process, practicum experience, simulations, clicker timing, metaverse and mixed reality, platform reform, & spiral model with Scratch	17	10, 12, 42, 6, 31, 9, 45, 8, 35, 40, 44, 15, 34, 27, 37, 7, 25
Technology and interface	Interface elements, social networks, mobile and classroom tech, automation and integrity, platforms and data tech, & technology type and time	13	6, 41, 33, 45, 22, 21, 23, 17, 44, 34, 27, 5, 16
Engagement and outcomes	Motivation and engagement, satisfaction, academic achievement, ICT and digital literacy, Information literacy, skills and stress, analytical reading, & player satisfaction	19	10, 12, 42, 19, 6, 31, 43, 9, 8, 20, 1, 35, 23, 40, 44, 27, 37, 7, 25
Cultural and context	Power distance and culture, institutional support, language and home access, & generation traits and roles	6	41, 3, 33, 18, 15, 16

Academic engagement and digital readiness explain achievement in e-learning (Kim et al., 2019). Self-regulated learning connects strategy use to online engagement for digital natives (Wang et al., 2022).

Gamified learning is present as design logic. Professors talk about game cycles and iterative judgment behavior feedback loops (Armstrong et al., 2022). A recent meta-analysis indicates a "positive impact on motivation and academic performance" when gaming dynamics align with the goal (Chong et al., 2024).

Designs are still based on basic learning theories. Constructivism and constructionism direct creative processes and item creation using Scratch and analogous tools (Sayavaranont et al., 2018). Active learning and self-paced learning facilitate student autonomy and agency (Beaudoin & Avanthey, 2022). Andragogy, with its focus on relevance and goals, shows that adults can learn (Barry et al., 2016).

Competence and literacy frameworks influence teacher preparedness. UNESCO ICT CFT and TPACK appear alongside information literacy criteria (Wang & Ko, 2022). A digital learning capacity framework emphasizes learner autonomy regarding time, location, trajectory, and pace (Zhuang et al., 2016).

Sociocultural and critical views are a smaller but important strand. Cultural interface design follows Hofstede dimensions as guidance (Nordin et al., 2022). Critical pedagogy and third space approaches surface for equity and community practices (Guerra-Nunez, 2017). Web environments are seen as transforming communication collaboration and learning (Lahuerta-Otero et al., 2018).

Generational constructs are common but contested. Several papers assume digital natives as a design premise, for example "new generation of students who are digital natives" (Cuevas-Ortuño & Zavala, 2024). Other work questions this assumption and calls for nuance (Gulatee & Combes, 2018). Attitude strength reminds us that stable preferences can overshadow the tool itself. "I am fine with any technology as long as it does not make trouble so that I can concentrate on my study" (Nistor et al., 2019).

The field uses acceptance models to make predictions, but it often needs incentives and pedagogy frames to really help students learn better. Gamification is most effective when integrated with flow, challenge, and feedback, rather than solely with points or competition. Frameworks for competency and literacy are important for teachers to use and for the curriculum to be in line with what they teach. Cultural and critical viewpoints exist but are not sufficiently utilized. They can clarify discrepancies that adoption models overlook. The digital natives lens is common, but not enough. Design should be based on talent, motivation, culture, and context, not on age designations.

Acceptance and adoption dominates the field (**Table 3**). Nineteen studies track classic acceptance constructs. Many repeat the trio "perceived usefulness" "perceived ease of use" and "behavioral intention to use" (Efiloğlu Kurt, 2022). Some add "compatibility" and "cognitive absorption" and "privacy and security" and quality factors such as service quality and system quality (Marcus et al., 2022). A smaller group reports "actual use" as a behavioral outcome (Motamedi & Marcus, 2024). The message is clear. Adoption models set the baseline for research with digital generations.

Engagement and outcomes is equally visible with nineteen studies. Work links design or acceptance to motivation and satisfaction and grades. One strand measures motivational energy using "MUSIC components" that is empowerment and usefulness and success and interest and caring (Cuevas-Ortuño & Zavala, 2024). Another strand ties attitudes and digital readiness to achievement such as GPA (Kim et al., 2019). Studies also track skill growth in ICT and information literacy and soft skills and stress (Wang & Ko, 2022).

Learner characteristics appears in eleven studies. Self-efficacy and enjoyment are frequent and link to intention and use (Fitriati et al., 2025). Some work adds personality and learning style and GPA to explain behavioral intention and use (Motamedi & Marcus, 2024). Digital nativity and readiness also mediate engagement and outcomes (Wang et al., 2022). These variables remind us that design does not act in a vacuum.

Pedagogical design is strong with seventeen studies. Many test gamification and simulations and hybrid sequences. Examples include "gamification techniques" and "game dynamics" with reported gains in perception and engagement (Chong et al., 2024). Hybrid process work describes phases such as "preparation" "presentation" "practice" and "progress reports" (Napaporn et al., 2023). There are focused interventions such as "pre lecture" and "post lecture" clickers (Toothaker, 2018) and the Scratch spiral with "analyze inspire educate imagine create experience share reflect evaluate imagine" (Sayavaranont et al., 2018). Several studies reform a platform or sequence and then track grades and stress and work time (Beaudoin & Avanthey, 2022).

Technology and interface covers thirteen studies. Some look at interface rules shaped by culture and report the importance of "color" "graphics" "layout" and "navigation" (Nordin et al., 2022). Others study social network choices such as Facebook and Twitter and Instagram for satisfaction and willingness to repeat (Lahuerta-Otero et al., 2018). A systems strand adopts IoT and big data and AI to drive engagement and performance metrics (Mehmood et al., 2017). Device and time trends also appear in ownership and access research (Gulatee & Combes, 2018).

Cultural and context is the least covered area with six studies. Still, results are concrete. Interface preferences vary with the power distance value in a culture (Nordin et al., 2022). Language and home access issues shape empowerment and motivation for foreign born learners (Guerra-Nunez, 2017). Studies on institutional support for digital game based learning show that context can speed or block adoption (Armstrong et al., 2022).

Cross category pattern. Many studies pair acceptance variables with design or interface moves and then evaluate engagement or achievement. For example, metaverse and mixed reality and active learning appear together with motivation and grades (Cuevas-Ortuño & Zavala, 2024). This supports a simple claim. Perceptions and design act together.

Perception scales are common. Objective traces are less common but present. Examples include grades and completion and platform logs and system performance and anti-plagiarism data (Beaudoin & Avanthey, 2022).

Table 4 shows broad support for acceptance factors. Many studies report effects of usefulness, ease, enjoyment, and support on intention and use. "Perceived enjoyment and complexity and facilitating conditions significantly affect behavioral intention" (Efiloğlu Kurt, 2022). Background matters too. "Learning style and personality had significant relationships with every TAM factor" (Motamedi & Marcus, 2024). Infrastructure also shapes adoption. Internet quality connects to intention and ease (Motamedi & Marcus, 2024). Service quality connects to satisfaction and continued use (Abu Seman et al., 2018).

Motivation and engagement are frequent outcomes of design. Game elements, clear rewards, and immersive or social activities lift energy and focus. "Students highly valued immediate and transparent rewards" (Chong et al., 2024). Serious games meet flow criteria and score well on satisfaction (Abd El-Sattar, 2023). Experiential simulations spark enthusiasm (Rimanelli & Gurba, 2019). Yet competition does not fit all learners (Buckley et al., 2017).

Table 4. Findings of the studies

ID	Study	A	ME	LO	SRC	LC	PUX	II	ES	IA
1	Abd El-Sattar (2023)		√							
2	Abu Seman et al. (2018)	√								√
3	Acosta-Enriquez et al. (2024)	√							√	
4	Armstrong et al. (2022)							√		
5	Bagdi et al. (2023)	√								√
6	Barry et al. (2016)						√			
7	Beaudoin and Avanthey (2022)		√	√						
8	Buckley et al. (2017)		√							
9	Caratozzolo et al. (2021)			√		√				
10	Castro et al. (2022)					√		√		
11	Chong et al. (2024)		√							
12	Cripps (2020)						√	√		
13	Cuevas-Ortuño and Zavala (2024)		√	√						
14	Efiloğlu Kurt (2022)	√								
15	Fitriati et al. (2025)	√								
16	Guerra-Nunez (2017)		√			√				
17	Gulatee and Combes (2018)					√	√			
18	Gulateee et al. (2018)					√	√			
19	Jukic and Skojo (2021)							√		
20	Kim et al. (2019)			√						
21	Lahuerta-Otero et al. (2018)		√				√			
22	Lahuerta-Otero et al. (2019)		√				√			
23	Li et al. (2017)						√			
24	Marcus et al. (2022)									
25	Matijević et al. (2017)							√		
26	Meet et al. (2022)	√								
27	Mehmood et al. (2017)			√	√					
28	Motamedi and Marcus (2024)	√								√
29	Motamedi et al. (2021)	√							√	
30	Muchsini et al. (2021)	√			√					
31	Napaporn et al. (2023)			√						
32	Nistor et al. (2019)	√								
33	Nordin et al. (2022)						√			
34	Petrovic (2017)		√				√			
35	Rimanelli and Gurba (2019)		√	√						
36	Rønningsbakk (2020)					√	√			
37	Sayavaranont et al. (2018)			√						
38	Šorgo et al. (2016)					√				√
39	Tick (2018)	√							√	
40	Toothaker (2018)		√	√						
41	Van Wyk (2022)						√			
42	Wang and Ko (2022)					√				
43	Wang et al. (2022)				√					
44	Wu (2021)		√							√
45	Wu et al. (2017)		√							
46	Zhuang et al. (2016)				√	√				

Note. A: Acceptance; ME: Motivation engagement; LO: Learning outcomes; SRC: Self-regulation capacity; LC: Literacy competence; PUX: Preferences UX; II: Instructor institution; ES: Ethics security; IA: Infrastructure access

Learning outcomes depend on engagement and pedagogy. Engagement predicts achievement (Kim et al., 2019). Structural reform with feedback and pacing can raise grades and reduce stress (Beaudoin & Avanthey, 2022). Immersive tools by themselves may not change grades. "No significant difference" in achievement appears in one metaverse lab study (Cuevas-Ortuño & Zavala, 2024).

Self-regulation and capacity act as bridges. Self-regulated learning mediates the path from digital native traits to engagement (Wang et al., 2022). Activity data also links to performance. Students who interact more tend to score higher (Mehmood et al., 2017).

The digital native idea does not guarantee literacy. Many findings show gaps in information literacy and professional ICT competence. "Digital native students do not naturally transform into teachers with ICT

Table 5. Challenges in using technologies for digital generations

Category	Code	Challenge summary	Typical solutions	Key references
Ethics, security, and integrity	Ethical risk and integrity, data accuracy anxiety, cognitive offloading concern, & security awareness gap	Cheating, misinformation, privacy, accuracy concerns, overreliance	Ethics training and policies, academic and ethical oversight, security guidance	2, 5, 39
Access and infrastructure	Infrastructure and access gaps, interface and UX quality, & platform reliability and usability	Bandwidth, device and data cost barriers, unstable platforms, weak UX	Shift to reliable platforms, staff training, low bandwidth options, UX improvements	17, 30, 16, 23, 33, 40
Human factors student side	Forced adoption shock, learning curve and complexity, student control limits, digital literacy and meta-literacies gap, & emotional load and motivation	Stress, low control, steep learning curve, gaps in information literacy	Real-time feedback, careful gamification, more exercises, integrate IL standards	6, 12, 38, 7
Human factors teacher and institution	Teacher capacity and resistance & governance and policy need	Limited know-how and time, resistance, weak institutional support	Workshops and mentoring, institutional support models, clear governance and policies	3, 18, 25, 2
Pedagogy and curriculum fit	Pedagogy-tech misalignment & need for scaffolds and F2F touchpoints	Tools do not align with reading and disciplinary needs	Pedagogical frameworks, blended design with F2F anchors, structured scaffolds	31, 19, 9, 6
Assessment and policy environment	Assessment pressure blocks innovation & pricing and value signals	High stakes tests and missing incentives limit innovation	Credit recognition, teacher encouragement, align evaluation with digital learning	42, 26
Research design constraints	Method limits and generalizability	Self-report bias, single site, small samples, cross-sectional evidence	Mixed methods, larger diverse samples, experimental manipulation, qualitative depth	28, 32, 22, 21, 40, 43

competency" (Wang & Ko, 2022). Only specific tool skills predict information literacy and device ownership is not enough (Šorgo et al., 2016).

Students show clear preferences and UX expectations. They prefer mobile access, micro content, and student centered visuals. There is a push for collaboration and flexible formats like podcasts and blogs (Li et al., 2017; Nordin et al., 2022; Van Wyk, 2022). Instructors and institutions need support and fit for tools. Lecturers often lack suitable games or know how. Many still teach in teacher centered ways (Armstrong et al., 2022; Matijević et al., 2017).

Ethics and security shape trust and sustained use. Perceived ethics and concerns influence use for AI tools like ChatGPT (Acosta-Enriquez et al., 2024). Many students do not check system security even when they care about their data (Tick, 2018).

The challenges stated in the studies were grouped under 7 categories (**Table 5**). One of them is "ethics, security, and integrity". Student trust is fragile. Learners worry about cheating, misinformation, privacy, and accuracy. One study notes "concerns about potential fraud, misinformation, and fairness issues" and doubts about "the accuracy of the data" from AI tools (Acosta-Enriquez et al., 2024). Security habits are also weak. Students want clear help channels for incidents, for example "whom to turn in case of IT security problems" (Tick, 2018). Ethics training, clear policies, and teacher oversight reduce risk. In rich media settings, academic and ethical oversight for online videos is important (Barry et al., 2016).

Second one is about access and infrastructure. Adoption stalls when basics fail. Bandwidth, device cost, and unstable platforms lower engagement. "The technology didn't always work" is a prevalent problem (Toothaker, 2018). Students are also less likely to use an interface if it doesn't look or feel good, as shown by low engagement when the interface quality is poor (Nordin et al., 2022). More stable platforms, staff training, low-bandwidth alternatives, and UX updates are some of the practical solutions (Gulatee & Combes, 2018; Muchsini et al., 2021).

Third challenge is related to human factors on the student side. Motivation and control matter. The sudden shift online created stress and resistance. One comment says, "technology is useful but sometimes so stressful" (Cripps, 2020). New platforms bring a learning curve and some settings reduce student agency, which lowers eMpowerment and success scores (Cuevas-Ortuño & Zavala, 2024). Everyday tech use does not equal academic information literacy, and instructors often overestimate student skill (Šorgo et al., 2016). Helpful moves include real time feedback, careful gamification, more targeted practice, and explicit IL standards.

Human factors on the teacher and institution side is for one of challenges. Capacity and time shape practice. Lecturers report resistance and limit know how for game based or digital methods (Armstrong et al., 2022). Many teachers also report low confidence with digital media for teaching (Matijević et al., 2017). Workshops, mentoring, and institutional backing help. Clear governance aligns ethics and practice across courses (Acosta-Enriquez et al., 2024; Jukic & Skojo, 2021).

Pedagogy and curriculum fit is another challenges stead in the studies. Technology works when it fits the task. Several studies report a lack of alignment between tools and disciplinary or reading goals. One research talks about how there isn't enough integration between reading methodologies, hybrid pedagogies, and new learning tools for analytical reading (Napaporn et al., 2023). Heavy content loads can also make students lose energy, thus scaffolding and some face-to-face connections help them keep going (Beaudoin & Avanthey, 2022). Use pedagogical frameworks first, then select tools.

Sixth challenge is related to assessment and policy environment. Rules and incentives steer behavior. Willingness to try new ICT falls when courses are dominated by high stakes exams (Wang & Ko, 2022). Clear incentives lift uptake. "MOOC developers should consider price value" and universities should recognize credits and encourage enrollment (Meet et al., 2022). Align evaluation and credit with the digital tasks you want students to do.

Research design constraints is seventh challenges. Evidence quality is uneven. Many studies use self-report, single sites, and small samples, which limits generalization (Motamedi & Marcus, 2024; Nistor et al., 2019; Wang & Ko, 2022). The field requires larger and more varied samples, integrated methodologies, and designs that evaluate modifications.

As a result of challenges, barriers accumulate. Teachers are careful and pupils are worried because the infrastructure is weak and the policy is not clear. When pedagogy is the main focus and institutions help, even basic tools can get people more involved. People shouldn't just presume that they know about ethics and security. The quickest wins come from strong interfaces, clear literacies, and incentives that are in line with each other.

Most recommendations call for broader and more diverse samples (**Table 6**). One clear line is to move beyond a single generation or single campus. For example, "expand the scope of the study to include participants from different generations, as well as those from various academic disciplines and cultures" (Acosta-Enriquez et al., 2024). Calls for larger and more varied samples repeat across studies such as Wang and Ko (2022) and Kim et al. (2019).

Measurement work is a second line. Many papers ask for better instruments and stronger evidence. Authors request new or improved scales, mixed objective and subjective measures, and formal validity checks. For example, "incorporate both objective and subjective measures" (Motamedi & Marcus, 2024) and "performing confirmatory factor analysis" (Motamedi et al., 2021). Model extensions are also common, such as "extend UTAUT2 with additional constructs" (Meet et al., 2022).

Design rigor is a third line. Longitudinal designs, comparative designs, and more robust analyses are emphasized. Efiloğlu Kurt (2022) calls for longitudinal work. Cuevas-Ortuño and Zavala (2024) ask for "other evaluation instruments" and for stronger analyses to reach "a more robust conclusion." Barry et al. (2016) propose comparative studies across resource types.

Pedagogy and design appear as actionable guidance. Recommendations focus on metacognition, meta-literacy, and self-regulation. "Metacognitive and meta-literacy strategies must form the foundation in

Table 6. Recommendations for future researchers

Category	Definition	Representative codes	Key studies
Sampling and diversity	Recommendations about who to study and how to improve generalizability	Cross-generation and cross-culture sampling, larger and broader samples, include teachers and other roles, gender balance, multi-institutional sampling	2, 28, 42, 4, 43, 26, 24, 33, 9, 18, 20, 1, 22, 21, 23, 38, 14, 25
Measurement and model refinement	Recommendations about instruments, constructs, validity, and evidence	Develop new scales, use objective and subjective measures, reliability and CFA, extend TAM and UTAUT2, power analysis, refine survey items, use log data	2, 28, 42, 26, 24, 29, 20, 32, 46
Design and methodology	Recommendations about research designs and analytic rigor	Longitudinal designs, comparative studies, mixed methods, robust statistics, additional evaluation instruments, experimental comparisons	12, 13, 4, 43, 26, 24, 9, 8, 20, 1, 21, 23, 5
Pedagogy and instructional design	Recommendations about teaching strategies and learning design	Metacognition and meta-literacy, agency and self-regulation, classroom management, 21st century skills	43, 41, 8, 18, 38
Technology and infrastructure	Recommendations about platforms, tools, and systems	Platform evolution, automatic graders and plagiarism tools, smart education visualization, MOOC and DGBL enhancements, system and IoT capacity	12, 19, 6, 26, 3, 45, 27
Equity, access, and ethics	Recommendations about fairness, inclusion, and responsible use	Digital equity and inclusion, accessibility and barriers, IT security awareness, ethics of AI, information literacy	2, 31, 41, 38, 39
Domain and context expansion	Recommendations to apply or scale interventions across contexts and subjects	Apply to other courses and disciplines, scale across levels and institutions, teacher training, specific domain studies	10, 12, 9, 8, 11, 35, 23, 5
Monitoring and continuous evaluation	Recommendations to track technology use and outcomes over time	Ongoing monitoring of tech use and competencies, continuous evaluation of LMS adoption	17, 16
Theory development	Recommendations to build or refine conceptual frameworks	Improve digital learning capacity frameworks, new research topics and Education 4.0, extend adoption models	19, 26, 8, 46

preparing learning" (Van Wyk, 2022). "Teachers should not only impart knowledge but also facilitate students with more self-regulated learning strategies" (Wang et al., 2022).

Technology and infrastructure updates are concrete. Beaudoin and Avanthey (2022) point to platform evolution, automatic correction, and plagiarism detection. Wu (2021) calls the "advancing visualization of smart teaching and learning" a key direction. Work on MOOCs and game-based learning also requests design guidance and institutional support, for example Armstrong et al. (2022).

Equity, access, and ethics cut across topics. Van Wyk (2022) links agency with "social justice, inclusion and digital equity." Tick (2018) urges development of student IT security awareness. Acosta-Enriquez et al. (2024) call for ethical scales and demographic comparisons in AI use.

Finally, the set stresses application across contexts and continuous monitoring. "Apply this virtual laboratory in other courses" to reach more students (Cuevas-Ortuño & Zavala, 2024). Universities should keep "ongoing monitoring and evaluation" of competencies and technology use (Gulatee & Combes, 2018).

Figure 1 synthesizes the review into a process model of how technology use translates into learning. The left-to-right *core pathway* proposes that learners' *acceptance/adoption* of a tool or platform (e.g., perceived usefulness, ease of use, social influence, and facilitating conditions) increases their *motivation/engagement* (interest, effort, and participation). Heightened engagement then improves *learning outcomes*, including achievement and skill development. The model further specifies a *mechanism*: *self-regulation*–goal setting, monitoring, strategy use–*mediates* the engagement → outcomes link by converting engaged activity into effective, outcome-relevant study behaviors.

Surrounding factors condition each stage. *Infrastructure/access/UX* (reliability, bandwidth, device availability, and usability) primarily affects *acceptance*, enabling or constraining initial uptake. *Institution & instructor support* (guidance, feedback, workload policies, professional capacity) primarily shapes *engagement*, sustaining students' ongoing participation. *Design & pedagogy* (alignment to outcomes, active learning,

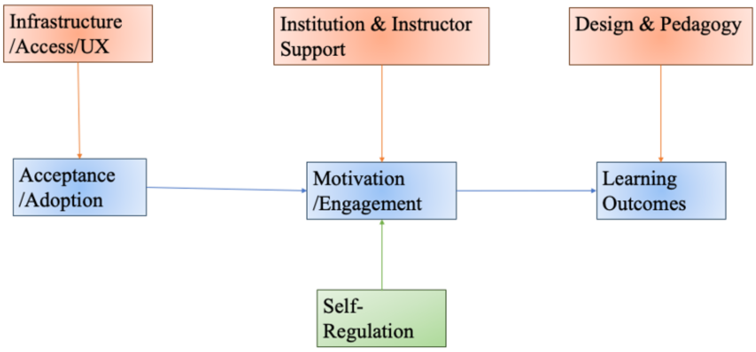

Figure 1. Pathway of using technologies for digital generations (Figure created by the authors)

gameful/immersive tasks) primarily influences *outcomes,* ensuring that engaged activity targets constructs that matter for learning. Together, these moderators explain variability across settings and clarify why similar technologies can yield different results in different contexts.

DISCUSSION

This thorough scoping review carefully looked at the current state, problems, and future orientations of educational tools for digital generations. Our findings indicate that, despite substantial advancements in this domain, there exists a pressing necessity to fortify theoretical underpinnings and enhance practical implementations.

The Dominance and Limitations of Technology Acceptance Models

Our research findings indicate that the TAM and UTAUT models hold a preeminent status in the educational technology domain, employed in 19 studies. This situation supports the concerns highlighted by Granic (2022) regarding the "unidimensional approach of technology acceptance research" in systematic reviews. The repetitive use of variables such as perceived usefulness, ease of use, and behavioral intention particularly limits the theoretical diversity of the field.

Nonetheless, our data suggest that motivation and engagement frameworks (MUSIC model, ARCS-V, and flow theory) are becoming progressively significant. This underscores the need for multimodal approaches to comprehend the "complex effects of digital technologies on cognitive processes," as highlighted by Vedechkina and Borgonovi (2021). Given Gen Z students' brief attention span (8 seconds) and their expectations for ongoing feedback, the integration of acceptance models with motivational variables is essential.

Reconceptualization of the Digital Generation Concept

The existence of studies that challenge the "digital generation" notion in our research (Bennett et al., 2008; Selwyn, 2009) signifies a paradigm change in this domain. Our findings show that there are criticisms about Prensky's (2001) original "digital natives" theory not having enough evidence to back it up. The issue of "technological and biological determinism" identified by Kirschner and De Bruyckere (2017) is evidently reflected in the skill inadequacies reported among students in the studies.

The disintegration of the "digital native myth" articulated by Reid et al. (2023) corresponds with our findings. Our research underscores that mere exposure to digital devices does not inherently impart digital literacy abilities; instead, it necessitates systematic teaching. This underscores the significance of methodical instruction in particular skills, such as "lateral reading," as proposed by McGrew (2024).

Critical Role of Technology-Pedagogy Integration

Our findings indicate that the educational efficacy of technology is directly correlated with pedagogical design. According to Wu's (2023) meta-analysis, teacher guidance, systematic design, and collaborative approaches have a greater impact on deep learning. The success of hybrid learning models particularly supports the "careful coordination" principle emphasized by Strelan et al. (2020). The moderate to large effect size demonstrated by adaptive learning systems parallels the findings of Wang et al. (2024a) and reveals the potential of personalized learning. However, the necessity of teacher knowledge and skill development emphasized by Moltudal et al. (2022) for the success of these systems emerges as a significant challenge in our study as well.

Digital Divide and Equity Issues

The deepening of the digital divide in the post-pandemic period aligns with the findings of Golden et al. (2023). In our study, the 28% lack of internet access and 22.8% classroom resource usage problem supports the "persistent educational digital divide" reality emphasized by Pierce and Cleary (2024). The greater losses experienced by disadvantaged students during remote learning particularly confirms the findings of van de Werfhorst et al. (2022).

The positive impact of "computer-assisted learning and behavioral supports" on equity presented by Di Pietro and Castaño Muñoz (2025) is also supported in our findings. This demonstrates that not only technology access but also pedagogical support is critical for equity.

Generational Misalignment of Theoretical Frameworks and the Need for New Paradigms

A critical issue revealed by our findings is the incompatibility between the historical origins of existing theoretical frameworks and the realities of digital generations. Considering that TAM (1989), UTAUT (2003), and similar acceptance models were developed during the X and Y generation periods in the context of desktop computers and early internet technologies, it is clear that these models cannot fully capture the mobile-centered, social network-focused, and continuously connected learning experiences of digital generations.

The interaction of Gen Z and Gen alpha with technology is fundamentally different from previous generations' "technology adaptation" processes. These generations were born with technology; multi-screen usage, instant information access, and continuous social interaction constitute their natural learning environments. Therefore, the demands for "personalized, inclusive, and contextualized learning" emphasized by Hammad (2025) require new approaches beyond the "technology acceptance" paradigm of existing theoretical frameworks.

The "metacognitive strategies and AI integration" approach proposed by Chardonnens (2025) provides clues for this new paradigm. However, there is an urgent need to develop theoretical approaches to understand how digital generations' learning processes with technology occur in their natural environments including social media platforms, mobile applications, and game-based environments. This necessitates the development of new theoretical frameworks based on the "living with technology" paradigm rather than the "technology use" paradigm.

Future-Oriented Implications

The "acceptance → motivation → learning outcomes" process model revealed by our study has the potential to transcend the limitations of current theoretical understanding through the mediating role of self-regulation skills. To accurately represent the authentic learning experiences of digital generations, a shift from the conventional "technology acceptance" framework to the "technology-integrated life and learning" framework is essential.

Future study must prioritize the comprehension of how digital generations acquire knowledge within their inherent technological environments, such as learning on TikTok, collaborating on Discord, and disseminating information on Instagram. This approach will facilitate the creation of novel theoretical frameworks grounded in the comprehension of the distinct learning ecologies of digital generations, thereby departing from technological determinism.

CONCLUSION

This comprehensive scoping review systematically maps the current state of educational technologies for digital generations, the challenges encountered, and future directions. The analysis of 46 studies published between 2016 and 2025 reveals that, despite significant developments in this field, there are serious gaps in theoretical, methodological, and practical aspects. The main findings of our study show that the field of educational technology is dominated by technology acceptance models (TAM and UTAUT). The fact that these models, used in 19 studies, were developed during the X and Y generations and do not fully reflect the natural technology interaction patterns of digital generations highlights the need for a paradigm shift in the field.

Our findings indicate that digital learning infrastructures (n = 29) and mobile-social learning ecosystems (n = 22) are the dominant technology categories, while immersive technologies (VR and metaverse) and A applications are still under-researched. In particular, adaptive learning systems showing moderate to large impact sizes highlight the potential of personalized learning.

The study also reveals that the digital divide has deepened post-pandemic (28% lack of internet access, 22.8% issues with in-class resource usage) and that teacher preparedness deficiencies are one of the biggest barriers to technology integration.

Limitations of the Study

This study has some methodological limitations. First, our search strategy, which only included English-language publications, may have excluded potentially important studies in other languages. Second, the 2016–2025 time frame is relatively short, considering the rapid evolution of digital technologies. Third, the use of only the WoS and Scopus databases excluded studies found in other academic databases. Fourth, due to the nature of the scoping review methodology, the included studies were not quality assessed, and the findings were not weighted according to study quality. Finally, inconsistencies in the definition of the concept of "digital generation" across studies caused difficulties in comparisons.

Recommendations

Recommendations for researchers

Our findings indicate that existing technology acceptance models do not reflect the realities of digital generations. It is critical for researchers to develop new theoretical frameworks that incorporate social media-based learning, multitasking, and instant feedback expectations. The fact that 67% of studies use quantitative approaches highlights the need for qualitative and mixed-method research. In particular, ethnographic studies in the natural learning environments of digital generations (TikTok, Discord, and Instagram) are recommended. The cross-sectional nature of most of the existing studies makes it difficult to understand how technological acceptance processes change over time. Longitudinal studies with a follow-up period of at least 12 months are recommended.

Recommendations for educators

As our findings show, the educational impact of technology is directly correlated with pedagogical design. It is recommended that educators first determine their learning objectives and then select the appropriate technologies. The information literacy deficiencies highlighted in the studies necessitate the development of structured digital literacy programs. In particular, the systematic teaching of "lateral reading" and source evaluation skills is critical. Our findings indicate that hybrid approaches are more effective. Educators are advised to carefully coordinate face-to-face and online activities.

Recommendations for policy makers

The finding that 28% of the population lacks internet access highlights the need for comprehensive digital infrastructure investments. It is recommended that policy makers focus not only on providing devices, but also on ensuring sustainable internet access and technical support.

The teacher preparation deficiencies highlighted in the studies necessitate the design of systematic professional development programs. It is recommended that these programs cover pedagogical integration issues as well as technological skills. The increasing use of AI-based educational tools requires the development of clear policies on data privacy and academic integrity.

Recommendations for technology developers

Our findings show the critical impact of interface quality and user experience on acceptance. Developers are advised to design interfaces that meet Gen Z's mobile-centric, visually oriented, and social interaction expectations. The development of adaptive systems with medium to large impact should be prioritized. In particular, it is recommended that systems offering instant feedback and personalized learning paths be designed.

Future Research Directions

Future research should focus on understanding the learning processes of digital generations in their natural technological habitats. In particular, the effects of social media-based learning, micro-learning experiences, and AI-supported personal learning assistants should be investigated in depth. In addition, systematic examination of Gen alpha's interaction with educational technology is critical to understanding the unique characteristics of this generation. Cross-cultural studies and research on digital education experiences in developing countries will also enrich the global perspective of the field. This study provides a comprehensive mapping of the current state of educational technologies for digital generations, offering a roadmap for researchers, educators, and policymakers. The implementation of the recommended strategies will enable educational technology to better address the real learning needs of digital generations.

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REFERENCES

Abd El-Sattar, H. K. H. (2023). A new learning theory-based framework for combining flow state with game elements to promote engagement and learning in serious games. *Information Sciences Letters, 12*(56), 2663-2677.

Abu Seman, S. A., Hashim, M. J., Mohd Roslin, R., & Mohd Ishar, N. I. (2018). Millennial learners' acceptance and satisfaction of blended learning environment. In *Proceedings of the International Conference on University Learning and Teaching*. https://doi.org/10.24191/ajue.v15i3.7845

Acosta-Enriquez, B. G., Arbulú Ballesteros, M. A., Arbulu Perez Vargas, C. G., Orellana Ulloa, M. N., Gutiérrez Ulloa, C. R., Pizarro Romero, J. M., Gutiérrez Jaramillo, N. D., Cuenca Orellana, H. U., Ayala Anzoátegui, D. X., & López Roca, C. (2024). Knowledge, attitudes, and perceived Ethics regarding the use of ChatGPT among Generation Z university students. *International Journal for Educational Integrity, 20*, Article 10. https://doi.org/10.1007/s40979-024-00157-4

AECT. (2020). AECT definition for educational technology. *ACET*. https://www.aect.org/aect/about/aect-definition

Ahmed, V., & Opoku, A. (2022). Technology supported learning and pedagogy in times of crisis: The case of COVID-19 pandemic. *Education and Information Technologies, 27*, 365-405. https://doi.org/10.1007/s10639-021-10706-w

Alrawashdeh, G. S., Fyffe, S., Azevedo, R. F. L., & Castillo, N. M. (2024). Exploring the impact of personalized and adaptive learning technologies on reading literacy: A global meta-analysis. *Educational Research Review, 42*, Article 100587. https://doi.org/10.1016/j.edurev.2023.100587

Arksey, H., & O'Malley, L. (2005). Scoping studies: Towards a methodological framework. *International Journal of Social Research Methodology, 8*(1), 19-32. https://doi.org/10.1080/1364557032000119616

Armstrong, C., Roodt, S., & Mulaji, S. M. (2022). Using digital game-based learning to engage the net generation of students in higher education: Lecturers' perceptions in South Africa. In *Proceedings of the 2022 3rd International Conference on Next Generation Computing Applications*. https://doi.org/10.1109/NextComp55567.2022.9932253

Assefa, Y., Gebremeskel, M. M., Moges, B. T., Tilwani, S. A., & Azmera, Y. A. (2024). Rethinking the digital divide and associated educational in(equity) in higher education in the context of developing countries: The social justice perspective. *The International Journal of Information and Learning Technology, 42*(1), 15-32. https://doi.org/10.1108/ijilt-03-2024-0058

Bagdi, H., Bulsara, H. P., Sankar, D., & Sharma, L. (2023). The transition from traditional to digital: Factors that propel Generation Z's adoption of online learning. *International Journal of Educational Management, 37*(3), 695-717. https://doi.org/10.1108/ijem-01-2023-0003

Barry, D. S., Marzouk, F., Chulak-Oglu, K., Bennett, D., Tierney, P., & O'Keeffe, G. W. (2016). Anatomy education for the YouTube generation. *Anatomical Sciences Education, 9*(1), 90-96. https://doi.org/10.1002/ase.1550

Beaudoin, L., & Avanthey, L. (2022). How to help digital-native students to successfully take control of their learning: A return of 8 years of experience on a computer science e-learning platform in higher education. *Education and Information Technologies, 28*(5), 5421-5451. https://doi.org/10.1007/s10639-022-11407-8

Bennett, S., Maton, K., & Kervin, L. (2008). The 'digital natives' debate: A critical review of the evidence. *British Journal of Educational Technology, 39*(5), 775-786. https://doi.org/10.1111/j.1467-8535.2007.00793.x

Blundell, C. N., Mukherjee, M., & Nykvist, S. (2022). A scoping review of the application of the SAMR model in research. *Computers and Education Open, 3*, Article 100093. https://doi.org/10.1016/j.caeo.2022.100093

Buckley, P., Doyle, E., & Doyle, S. (2017). Game on! Students' perceptions of gamified learning. *Educational Technology & Society, 20*(3), 1-10.

Caratozzolo, P., Alvarez-Delgado, A., & Sirkis, G. (2021). Fostering digital literacy through active learning in engineering education. In *Proceedings of the 2021 IEEE Frontiers in Education Conference* (pp. 1-6). IEEE. https://doi.org/10.1109/FIE49875.2021.9637304

Castro, A., Trindade, R., & Pereira, T. (2022). Proof of concept teaching for 21st century digital literacy in Portugal: A pedagogical approach towards a new educational model. In D. Passey, D., Leahy, L. Williams, J. Holvikivi, & M. Ruohonen, M. (Eds.), *Digital transformation of education and learning–Past, present and future. OCCE 2021. IFIP advances in information and communication technology, vol 642* (pp. 168-178). Springer. https://doi.org/10.1007/978-3-030-97986-7_14

Chan, C. K. Y., & Lee, K. K. W. (2023). The AI generation gap: Are Gen Z students more interested in adopting generative AI such as ChatGPT in teaching and learning than their Gen X and millennial generation teachers? *Smart Learning Environments, 10*, Article 60. https://doi.org/10.1186/s40561-023-00269-3

Chardonnens, S. (2025). Adapting educational practices for Generation Z: Integrating metacognitive strategies and artificial intelligence. *Frontiers in Education, 10*. https://doi.org/10.3389/feduc.2025.1504726

Cheng, X., Sun, J., & Zarifis, A. (2020). Artificial intelligence and deep learning in educational technology research and practice. *British Journal of Educational Technology, 51*(5), 1653-1656. https://doi.org/10.1111/bjet.13018

Chong, M. M., Subramanian, P., Ting, M., & Ying, L. J. (2024). An investigation into the perception of Gen Z students in higher education towards gamification techniques in learning computing subjects. In *Proceedings of the 2024 International Visualization, Informatics and Technology Conference*. https://doi.org/10.1109/IVIT62102.2024.10692814

Coldwell-Neilson, J. (2018). Digital literacy expectations in higher education. In M. Campbell, J. Willems, C. Adachi, D. Blake, I. Doherty, S. Krishnan, S. Macfarlane, L. Ngo, M. O'Donnell, S. Palmer, L. Riddell, I. Story, H. Suri, & J. Tai (Eds.), *Open oceans: Learning without borders. Proceedings ASCILITE 2018 Geelong* (pp. 103-112). ASCILITE Publications. https://doi.org/10.14742/apubs.2018.1922

Contrino, M. F., Reyes-Millán, M., Vázquez-Villegas, P., & Membrillo-Hernández, J. (2024). Using an adaptive learning tool to improve student performance and satisfaction in online and face-to-face education for a more personalized approach. *Smart Learning Environments, 11*, Article 6. https://doi.org/10.1186/s40561-024-00292-y

Cripps, T. (2020). We are mobile magicians but digital refugees: Helping prospective English teachers explore technology and ubiquitous learning. *Electronic Journal of Foreign Language Teaching, 17*(S1), 168-189. https://doi.org/10.56040/tncp171a

Cuevas-Ortuño, J., & Zavala, A. (2024). Combining discrete-event simulation with the metaverse to motivate students in higher education. In *Proceedings of the 2024 IEEE Global Engineering Education Conference* (pp. 1-5). IEEE. https://doi.org/10.1109/EDUCON60312.2024.10578770

Demir, M. (2024). A taxonomy of social media for learning. *Computers & Education, 218*, Article 105091. https://doi.org/10.1016/j.compedu.2024.105091

Di Pietro, G., & Castaño Muñoz, J. (2025). A meta-analysis on the effect of technology on the achievement of less advantaged students. *Computers & Education, 226*, 105197. https://doi.org/10.1016/j.compedu.2024.105197

Dron, J. (2021). Educational technology: What it is and how it works. *AI & SOCIETY, 37*, 155-166. https://doi.org/10.1007/s00146-021-01195-z

Efiloğlu Kurt, Ö. (2022). Learning with smartphones: The acceptance of m-learning in higher education. *Online Information Review, 47*(5), 862-879. https://doi.org/10.1108/oir-10-2021-0516

Fitriati, A., Anggoro, S., Talib, C. A., & Toh, T. L. (2025). The intention of Generation Z to use mobile learning: The role of self-efficacy and enjoyment. *Turkish Online Journal of Distance Education, 26*(1), 85-100. https://doi.org/10.17718/tojde.1445234

Golden, A. R., Srisarajivakul, E. N., Hasselle, A. J., Pfund, R. A., & Knox, J. (2023). What was a gap is now a chasm: Remote schooling, the digital divide, and educational inequities resulting from the COVID-19 pandemic. *Current Opinion in Psychology, 52*, Article 101632. https://doi.org/10.1016/j.copsyc.2023.101632

Granic, A. (2022). Educational technology adoption: A systematic review. *Education and Information Technologies, 27*, 9725-9744. https://doi.org/10.1007/s10639-022-10951-7

Guerra-Nunez, O. (2017). The use of digital educational technology and third spaces with foreign-born Latinos. *Journal of Latinos and Education, 16*(4), 323-337. https://doi.org/10.1080/15348431.2016.1257426

Gulatee, Y., & Combes, B. (2018). Are you sure this generation are digital natives? Case study: Thailand and Australia. In *Proceedings of the 2018 5th International Symposium on Emerging Trends and Technologies in Libraries and Information Services*. https://doi.org/10.1109/ETTLIS.2018.8485254

Gulateee, Y., Pagram, J., & Combes, B. (2018). Which tech will I use? Trends in students' use and ownership of technology in a Thai university, an ongoing study. *Journal of ICT Research and Applications, 12*(2), 138-153. https://doi.org/10.5614/itbj.ict.res.appl.2018.12.2.3

Hammad, H. S. (2025). Teaching the digital natives: Examining the learning needs and preferences of Gen Z learners in higher education. *Transcultural Journal of Humanities and Social Sciences, 6*(2), 214-242. https://doi.org/10.21608/tjhss.2025.346098.1303

Höfrová, A., Balidemaj, V., & Small, M. A. (2024). A systematic literature review of education for Generation alpha. *Discover Education, 3*, Article 125. https://doi.org/10.1007/s44217-024-00218-3

Huss, J. A. (2023). Gen Z students are filling our online classrooms: Do our teaching methods need a reboot? *InSight: A Journal of Scholarly Teaching, 18*, 101-112. https://doi.org/10.46504/18202306hu

Jukic, R., & Skojo, T. (2021). The educational needs of the alpha Generation. In *Proceedings of the 2021 44th International Convention on Information, Communication and Electronic Technology*. https://doi.org/10.23919/MIPRO52101.2021.9597106

Kim, H. J., Hong, A. J., & Song, H.-D. (2019). The roles of academic engagement and digital readiness in students' achievements in university e-learning environments. *International Journal of Educational Technology in Higher Education, 16*, Article 21. https://doi.org/10.1186/s41239-019-0152-3

Kirschner, P. A., & De Bruyckere, P. (2017). The myths of the digital native and the multitasker. *Teaching and Teacher Education, 67*, 135-142. https://doi.org/10.1016/j.tate.2017.06.001

Kus, M. (2025). A meta-analysis of the impact of technology related factors on students' academic performance. *Frontiers in Psychology, 16*. https://doi.org/10.3389/fpsyg.2025.1524645

Lahuerta-Otero, E., Cordero-Gutiérrez, R., & Izquierdo-Álvarez, V. (2018). Like it or die. In *Proceedings of the 6th International Conference on Technological Ecosystems for Enhancing Multiculturality*. https://doi.org/10.1145/3284179.3284336

Lahuerta-Otero, E., Cordero-Gutiérrez, R., & Izquierdo-Álvarez, V. (2019). Using social media to enhance learning and motivate students in the higher education classroom. In L. Uden, D. Liberona, G. Sanchez, & S. Rodríguez-González (Eds.), *Learning technology for education challenges. LTEC 2019. Communications in computer and information science, vol 1011* (pp. 351-361). Springer. https://doi.org/10.1007/978-3-030-20798-4_30

Lee, K., & Fanguy, M. (2022). Online exam proctoring technologies: Educational innovation or deterioration? *British Journal of Educational Technology, 53*(3), 475-490. https://doi.org/10.1111/bjet.13182

Levac, D., Colquhoun, H., & O'Brien, K. K. (2010). Scoping studies: Advancing the methodology. *Implementation Science, 5*, Article 69. https://doi.org/10.1186/1748-5908-5-69

Li, Z., Zhou, M., & Teo, T. (2017). Mobile technology in dance education: A case study of three Canadian high school dance programs. *Research in Dance Education, 19*(2), 183-196. https://doi.org/10.1080/14647893.2017.1370449

Marcus, V., Masrahi, A., & Motamedi, S. (2022). Generation Z and e-learning: COVID-19, personality, and technology acceptance. In *Proceedings of the Human Factors and Ergonomics Society Annual Meeting*. https://doi.org/10.1177/1071181322661183

Martin, F., Long, S., Haywood, K., & Xie, K. (2025). Digital distractions in education: A systematic review of research on causes, consequences and prevention strategies. *Educational Technology Research and Development*. https://doi.org/10.1007/s11423-025-10550-6

Matijević, M., Topolovčan, T., & Rajić, V. (2017). Nastavničke procjene upotrebe digitalnih medija i konstruktivističke nastave u primarnom i sekundarnom obrazovanju [Teachers' assessments of the use of digital media and constructivist teaching in primary and secondary education]. *Croatian Journal of Education, 19*(2). https://doi.org/10.15516/cje.v19i2.2411

McGrew, S. (2024). Teaching lateral reading: Interventions to help people read like fact checkers. *Current Opinion in Psychology, 55*, Article 101737. https://doi.org/10.1016/j.copsyc.2023.101737

Meet, R. K., Kala, D., & Al-Adwan, A. S. (2022). Exploring factors affecting the adoption of MOOC in Generation Z using extended UTAUT2 model. *Education and Information Technologies, 27*, 10261-10283. https://doi.org/10.1007/s10639-022-11052-1

Mehmood, R., Alam, F., Albogami, N. N., Katib, I., Albeshri, A., & Altowaijri, S. M. (2017). UTiLearn: A personalised ubiquitous teaching and learning system for smart societies. *IEEE Access, 5*, 2615-2635. https://doi.org/10.1109/access.2017.2668840

Mhlongo, S., Mbatha, K., Ramatsetse, B., & Dlamini, R. (2023). Challenges, opportunities, and prospects of adopting and using smart digital technologies in learning environments: An iterative review. *Heliyon, 9*(6), Article e16348. https://doi.org/10.1016/j.heliyon.2023.e16348

Moltudal, S. H., Krumsvik, R. J., & Høydal, K. L. (2022). Adaptive learning technology in primary education: Implications for professional teacher knowledge and classroom management. *Frontiers in Education, 7*. https://doi.org/10.3389/feduc.2022.830536

Motamedi, S., & Marcus, V. (2024). Impact of students' backgrounds on online learning behavior: Generation Z technology acceptance of e-learning technology during COVID-19. In *Proceedings of the 2024 ASEE Annual Conference & Exposition Proceedings*. https://doi.org/10.18260/1-2--47564

Motamedi, S., Marquis, K., & Levine, H. (2021). Understanding e-learning acceptance of Gen Z students: An extension of the technology acceptance model (TAM). In *Proceedings of the 2021 ASEE Virtual Annual Conference*. https://doi.org/10.18260/1-2--37956

Muchsini, B., Siswandari, Joyoatmojo, S., & Wiranto. (2021). Exploring perceived fits, attitudes, and self-efficacy: A case of digital natives' online learning behavior. *Journal of Physics: Conference Series, 1842*, Article 012013. https://doi.org/10.1088/1742-6596/1842/1/012013

Mutimukwe, C., Viberg, O., Oberg, L. M., & Cerratto-Pargman, T. (2022). Students' privacy concerns in learning analytics: Model development. *British Journal of Educational Technology, 53*(4), 932-951. https://doi.org/10.1111/bjet.13234

Napaporn, S., Maneewan, S., Thamwipat, K., & Nittayathammakul, V. (2023). The cloud-powered hybrid learning process to enhance digital natives' analytical reading skills. *International Journal of Advanced Computer Science and Applications, 14*(1). https://doi.org/10.14569/ijacsa.2023.0140168

Nistor, N., Stanciu, D., Lerche, T., & Kiel, E. (2019). "I am fine with any technology, as long as it doesn't make trouble, so that I can concentrate on my study": A case study of university students' attitude strength related to educational technology acceptance. *British Journal of Educational Technology, 50*(5), 2557-2571. https://doi.org/10.1111/bjet.12832

Nordin, H., Singh, D., Mansor, Z., & Yadegaridehkordi, E. (2022). Impact of power distance cultural dimension in e-learning interface design among Malaysian Generation Z students. *IEEE Access, 10*, 64199-64208. https://doi.org/10.1109/access.2022.3183117

Onjewu, A.-K. E., Godwin, E. S., Azizsafaei, F., & Appiah, D. (2024). The influence of technology use on learning skills among Generation Z: A gender and cross-country analysis. *Industry and Higher Education, 39*(2), 139-157. https://doi.org/10.1177/09504222241263227

Opesemowo, O. A. G., & Adekomaya, V. (2024). Harnessing artificial intelligence for advancing sustainable development goals in South Africa's higher education system: A qualitative study. *International Journal of Learning, Teaching and Educational Research, 23*(3), 67-86. https://doi.org/10.26803/ijlter.23.3.4

Petrovic, O. (2017). D-move: A mobile communication based Delphi for digital natives to support embedded research. In *Proceedings of the 13th International Conference Mobile Learning 2017*.

Phillips, T., & Ozogul, G. (2020). Learning analytics research in relation to educational technology: Capturing learning analytics contributions with bibliometric analysis. *TechTrends, 64*(6), 878-886. https://doi.org/10.1007/s11528-020-00519-y

Pierce, G. L., & Cleary, P. F. (2024). The persistent educational digital divide and its impact on societal inequality. *PLoS ONE, 19*(4), Article e0286795. https://doi.org/10.1371/journal.pone.0286795

Prensky, M. (2001). Digital natives, digital immigrants part 2: Do they really think differently? *On the Horizon, 9*(6), 1-6. https://doi.org/10.1108/10748120110424843

Rangel-Pérez, C., Gato-Bermúdez, M.-J., Musicco-Nombela, D., & Ruiz-Alberdi, C. (2021). The massive implementation of ICT in universities and its implications for ensuring SDG 4: Challenges and difficulties for professors. *Sustainability, 13*(22), Article 12871. https://doi.org/10.3390/su132212871

Reid, L., Button, D., & Brommeyer, M. (2023). Challenging the myth of the digital native: A narrative review. *Nursing Reports, 13*(2), 573-600. https://doi.org/10.3390/nursrep13020052

Rimanelli, M., & Gurba, K. (2019). Gaming in education and e-learning: Mock-trials, mock-elections and crisis-simulations for political sciences and communications courses. In *Proceedings of the International Conference on e-Learning 2019*. https://doi.org/10.33965/el2019_201909F030

Rønningsbakk, L. (2020). Digital natives and educational traditions. What changes when exchanging textbook content with Internet search? In T. C. Huang, T. T. Wu, J. Barroso, F. E. Sandnes, P. Martins, & Y. M. Huang (Eds.), *Innovative technologies and learning. ICITL 2020. Lecture notes in computer science(), vol 12555* (pp. 547-556). Springer. https://doi.org/10.1007/978-3-030-63885-6_59

Sayavaranont, P., Piriyasurawong, P., & Jeerungsuwan, N. (2018). Enhancing Thai Generation Z's creative thinking with Scratch through the spiral model. *International Journal of Learning Technology, 13*(3). https://doi.org/10.1504/ijlt.2018.095961

Selwyn, N. (2009). The digital native–Myth and reality. *Aslib Proceedings, 61*(4), 364-379. https://doi.org/10.1108/00012530910973776

Sergeeva, O. V., Zheltukhina, M. R., & Demir, S. (2025). From assistance to integrity: Exploring the role of AI in academic communication across Russian and Turkish campuses. *Frontiers in Communication, 10*. https://doi.org/10.3389/fcomm.2025.1479813

Soomro, K. A., Kale, U., Curtis, R., Akcaoglu, M., & Bernstein, M. (2020). Digital divide among higher education faculty. *International Journal of Educational Technology in Higher Education, 17*, Article 21. https://doi.org/10.1186/s41239-020-00191-5

Šorgo, A., Bartol, T., Dolničar, D., & Boh Podgornik, B. (2016). Attributes of digital natives as predictors of information literacy in higher education. *British Journal of Educational Technology, 48*(3), 749-767. https://doi.org/10.1111/bjet.12451

Stoltz, J. H., Bunt, B., & van Zyl, S. (2025). Leveling up learning: Enhancing self-directed learning in computer applications technology with Classcraft. *Education Sciences, 15*(2), Article 180. https://doi.org/10.3390/educsci15020180

Strelan, P., Osborn, A., & Palmer, E. (2020). The flipped classroom: A meta-analysis of effects on student performance across disciplines and education levels. *Educational Research Review, 30*, Article 100314. https://doi.org/10.1016/j.edurev.2020.100314

Strielkowski, W., Grebennikova, V., Lisovskiy, A., Rakhimova, G., & Vasileva, T. (2024). AI-driven adaptive learning for sustainable educational transformation. *Sustainable Development, 33*(2), 1921-1947. https://doi.org/10.1002/sd.3221

Szymkowiak, A., Melović, B., Dabić, M., Jeganathan, K., & Kundi, G. S. (2021). Information technology and Gen Z: The role of teachers, the Internet, and technology in the education of young people. *Technology in Society, 65*, Article 101565. https://doi.org/10.1016/j.techsoc.2021.101565

Tick, A. (2018). IT security as a special awareness at the analysis of the digital/e-learning acceptance strategies of the early Z Generation. In *Proceedings of the 2018 IEEE 22nd International Conference on Intelligent Engineering Systems* (pp. 45-50). IEEE. https://doi.org/10.1109/INES.2018.8523964

Toothaker, R. (2018). Millennial's perspective of clicker technology in a nursing classroom: A mixed methods research study. *Nurse Education Today, 62*, 80-84. https://doi.org/10.1016/j.nedt.2017.12.027

Tricco, A. C., Lillie, E., Zarin, W., O'Brien, K. K., Colquhoun, H., Levac, D., Moher, D., Peters, M. D. J., Horsley, T., Weeks, L., Hempel, S., Akl, E. A., Chang, C., McGowan, J., Stewart, L., Hartling, L., Aldcroft, A., Wilson, M. G., Garritty, C., … Straus, S. E. (2018). PRISMA extension for scoping reviews (PRISMA-ScR): Checklist and explanation. *Annals of Internal Medicine, 169*(7), 467-473. https://doi.org/10.7326/M18-0850

van de Werfhorst, H. G., Kessenich, E., & Geven, S. (2022). The digital divide in online education: Inequality in digital readiness of students and schools. *Computers and Education Open, 3*, Article 100100. https://doi.org/10.1016/j.caeo.2022.100100

Van Wyk, B. (2022). New kids on the block? Exploring technological preferences of a new generation. *European Conference on e-Learning, 21*(1), 432-437. https://doi.org/10.34190/ecel.21.1.446

Vedechkina, M., & Borgonovi, F. (2021). A review of evidence on the role of digital technology in shaping attention and cognitive control in children. *Frontiers in Psychology, 12*. https://doi.org/10.3389/fpsyg.2021.611155

Vizcaya-Moreno, M. F., & Perez-Canaveras, R. M. (2020). Social media used and teaching methods preferred by Generation Z students in the nursing clinical learning environment: A cross-sectional research study. *International Journal of Environmental Research and Public Health, 17*(21), Article 8267. https://doi.org/10.3390/ijerph17218267

Wang, C., Chen, X., Yu, T., Liu, Y., & Jing, Y. (2024a). Education reform and change driven by digital technology: A bibliometric study from a global perspective. *Humanities and Social Sciences Communications, 11*, Article 256. https://doi.org/10.1057/s41599-024-02717-y

Wang, P., & Ko, J. (2022). ICT competency and practicum of preservice teachers as digital natives: A mixed-method study. *Asia Pacific Journal of Education, 44*(4), 901-916. https://doi.org/10.1080/02188791.2022.2083581

Wang, X., Huang, R. T., Sommer, M., Pei, B., Shidfar, P., Rehman, M. S., Ritzhaupt, A. D., & Martin, F. (2024b). The efficacy of artificial intelligence-enabled adaptive learning systems from 2010 to 2022 on learner outcomes: A meta-analysis. *Journal of Educational Computing Research, 62*(6), 1348-1383. https://doi.org/10.1177/07356331241240459

Wang, X., Hui, L., Jiang, X., & Chen, Y. (2022). Online English learning engagement among digital natives: The mediating role of self-regulation. *Sustainability, 14*(23), Article 15661. https://doi.org/10.3390/su142315661

Wu, K.-C., Chen, C.-C., Chiu, T.-H., & Chiang, I. J. (2017). Transform children's library into a mixed-reality learning environment: Using smartwatch navigation and information visualization interfaces. In *Proceedings of the 2017 Pacific Neighborhood Consortium Annual Conference and Joint Meetings*. https://doi.org/10.23919/PNC.2017.8203526

Wu, Q. (2021). Networking college's smart education system based on omnidirectional interaction model. In *Proceedings of the 2021 2nd International Conference on Information Science and Education*. https://doi.org/10.1109/ICISE-IE53922.2021.00039

Wu, X.-Y. (2023). Exploring the effects of digital technology on deep learning: A meta-analysis. *Education and Information Technologies, 29*(1), 425-458. https://doi.org/10.1007/s10639-023-12307-1

Yalçın-İncik, E., & İncik, T. (2022). Generation Z students' views on technology in education: What they want what they get. *Malaysian Online Journal of Educational Technology, 10*(2), 109-124. https://doi.org/10.52380/mojet.2022.10.2.275

Yeung, K. L., Carpenter, S. K., & Corral, D. (2021). A comprehensive review of educational technology on objective learning outcomes in academic contexts. *Educational Psychology Review, 33*(4), 1583-1630. https://doi.org/10.1007/s10648-020-09592-4

Zhuang, R., Yang, J., Li, B., Zhang, Y., & Huang, R. (2016). The framework of digital learning capacity for digital natives. In *Proceedings of the 2016 IEEE 16th International Conference on Advanced Learning Technologies* (pp. 386-390). IEEE. https://doi.org/10.1109/ICALT.2016.130