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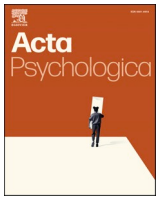

AI and the psychology of educational disruption: Historical patterns and cognitive implications

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ABSTRACT

Artificial intelligence (AI) and, concomitantly, large language models (LLMs), emerge as an unprecedentedly disruptive force in education. We contend that AI is not just a technological disruption but also a psychological inflection point that reconfigures the evolving contours of cognition, motivation, and agency under technological pressure. Using Disruptive Innovation Theory (DIT), the Technological Pedagogical Content Knowledge (TPACK) framework, and Postdigital Education Theory (PET), AI is located in a series of histories of educational disruptions (printing, radio, Internet, and mobile / cloud). These lenses highlight recurrent psychological themes that transcend technological epochs: novel literacies, evolving learner motivation/autonomy, rising human cognitive load, and the lag in institutional adaptation. Conceptual synthesis demonstrates a crystallization of psychological effects—bifurcated epistemic fluidity, blurred authorship, and identity negotiation/formation—-under AI. Theoretical triangulation of the DIT, TPACK, and PET frameworks articulates the entangled, ripple effects of AI-triggered changes transcending institutional, pedagogical, and psychological levels. To support the enactment of these ideas, we delineate staged AI-responsive literacies (autonomy, vigilance, regulation, ethics) and propose operational strategic supports for learners, educators, and institutions. We conclude by reviewing the limitations of the conceptualization and charting future research directions in empirical classrooms, identity shifts, and equity in institutional responses. Overall, we argue that AI as a "disruption" must be repositioned not only as a technical intervention but also as a psychological and educational imperative to nurture autonomy, metacognition, and equity.

1. Introduction

The history of educational systems is replete with moments of cognitive dissonance (Heaton & Quan, 2023) and how it plays a key role in changing practice (Treacy & Leavy, 2023). Moreover, the dominance of models of teaching and learning is often ruptured or overturned by emerging technologies (Lee & Lee, 2020; Lehr et al., 2025). Within these critical moments, fundamental psychological processes and constructs, such as attention, memory, motivation, and self-efficacy, are called into question. Artificial Intelligence (AI), and particularly large language models (LLMs) like ChatGPT, represent such a moment of educational disruption (Amiri, 2025; Bozkurt et al., 2023; Halagatti et al., 2023). While commonly presented as an unprecedented technological advance (Sarpong, 2025), the psychological disruptions of AI and how it shapes cognition, reconfigures motivation (Neji et al., 2023), and disrupts institutional trust can be better understood through historical analogy.

History shows that each major educational technology has redefined psychological processes central to learning (Spencer, 2017). The printing press, for example, dispersed authority and reshaped habits of interpretation and cognition autonomy (Li, 2023; More, 2025). Radio and film reorganized attention and multimodal processing by drawing out auditory and visual modes in novel ways (Preston, 2017; Slotten, 2008). The personal computer individualized learning, shifting metacognition and self-regulation, and the Internet broadened epistemic access and destabilized memory-based approaches to assessment (Gunn & Lynch, 2021).

Mobile and cloud-based tools have recently moved learning into an asynchronous, learner-centric 'cloud' (Kerimbayev et al., 2023). From these disruptions, institutional resistance and uneven accommodation periods show how psychological readiness often determines whether new technologies become normalized (Zakerabasali et al., 2021). As Fukuyama (2017) reminds us, these moments also demand new forms of

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social ordering and trust — a factor not far removed from current controversies regarding AI's function in educational practice.

Every major educational technology in history, from the printing press (Li, 2023; More, 2025), radio (Preston, 2017; Slotten, 2008), film and television, personal computers, the Internet, and most recently, mobile and cloud-based tools, has ushered in structural changes in cognition (Sarpong, 2025), pedagogical relations and various forms of learning space. The printing press dispersed authority, facilitated independent reading, and informed new habits of mind around interpretation, representation, and analysis (More, 2025). Radio and film engaged auditory and visual modes and reorganized attention and multimodal processing (Preston, 2017)—the personal computer (PC) individualized learning and modified self-regulation and metacognition. The Internet widened epistemic access and questioned memory technologies in form-based assessment (Gunn & Lynch, 2021). Mobile technologies made learning asynchronous and grounded in learner-centered environments (Kerimbayev et al., 2023). Institutions resisted the change (Zakerabasali et al., 2021), educators adapted to it unevenly, and students developed new literacies independently without systematic psychological support.

From a psychological perspective, AI alters fundamental learning processes, shifting cognitive loads as learners outsource production to AI. However, this should occur with an increased focus on competing demands of credibility and bias (Schmitt, 2021). Motivation and autonomy are redefined, as some students feel agency and empowerment in AI-enabled creative opportunities, while others feel estranged when effort and investment are externalized (Holmes et al., 2019; Pedro et al., 2019). Identity and authorship become unsettled as learners confront what it means to "know," to "write," or to "create" within contexts where such outputs are now potentially co-constructed with, or off-loaded onto, algorithms (Zhang et al., 2025).

Within this context, AI's introduction and utilization across educational platforms represents not just a technological but a cognitive disruption (Ghiasi, 2024; Radanliev, 2024; Zhong & Zhao, 2025), as LLMs can produce and transmit information, simulating reasoning and outputting structured language that mimics and often surpasses a student's performance. Consequently, these novel LLM tools disrupt established authorship, comprehension, and assessment theories in education. Learners are increasingly likely to co-construct meaning with machines, rendering academic questions of understanding, originality, and intellectual effort more problematic (Mazzi, 2024). It is increasingly complex for educators to validate student work and scaffold meaningful learning when AI can surreptitiously complete much of the academic process (George, 2023). Educational psychologists have begun to consider how AI is reshaping cognitive and motivational processes at the core of academic work, asking questions like:

- How does relying on AI impact memory consolidation, allocation of attentional resources, or development of problem-solving strategies?
- How are students' intrinsic motivation, competence, or cognitive autonomy affected?

This paper draws on three theoretical frameworks at the intersection between educational innovation and psycho-social adaptation to address the above problems. These are: Disruptive Innovation Theory (Christensen, 1997, 2021; Christensen et al., 2016; Cristofaro & Giardino, 2025) articulates how peripheral technologies can eventually supplant dominant practice while providing an understanding of the ways that AI might undermine existing assessment and teaching structures (McCausland, 2023; Păvăloaia & Necula, 2023).

The Technological Pedagogical Content Knowledge (TPACK) framework (Celik, 2023; Mishra & Koehler, 2006; Schmid et al., 2024) suggests that technological fluency (knowledge), content knowledge, and pedagogical design must now also accommodate ethical use (Aljabr & Al-Ahdal, 2024), algorithmic knowledge, and AI-enabled cognition. Mishra et al.(2023) also asserted that the TPACK framework can be used to discuss what types of knowledge teachers must have to employ GenAI tools effectively.

Postdigital Education Theory (PET) (Jandrić et al., 2018) posits AI as an inextricable feature in 'everyday' educational thinking and practice, which challenges dualisms such as digital and analog, tool and user, and cognition and computation (Hayes et al., 2024).

Across these frameworks, historians find steady models of how past technologies were introduced and received: 1) initial skepticism (Trieste & Turchetti, 2024), 2) partial adoption (Aly et al., 2018), 3) moral panic (García-Peñalvo, 2023), and 4) eventual normalization. They also show how each disruption redefined psychological suppositions and what attending, comprehending, or learning means. However, the AI disruption seems more wide-ranging and profound in its reach and depth. It spans psychological constructs from cognitive load and epistemic trust to motivation (Gunn & Lynch, 2021), self-regulation, and ethical reasoning. Educators and educational institutions need to reconsider these practices as much for their psychological validity as their technical viability.

Ultimately, this paper suggests that the influence of AI on education is less about state-of-the-art technology and more about educators' and learners' psychological readiness (Pedro et al., 2019). Instead of panicking or relaxing too comfortably, educational psychology provides us with the ways to critically and creatively reframe AI. It asks us to challenge prevailing assessments, promote metacognitive engagement, and design the ecology of learning in which human judgment is scaffolded with technological augmentation (Luckin et al., 2022). History demonstrates that disruption leads to inevitable change, which catalyzes learning, adaptation, and social ordering (Fukuyama, 2017).

To guide this conceptual exploration, we pose three overarching research questions (RQs):

RQ1. How can historical patterns of technological disruption in education help us understand AI's psychological and pedagogical impact today equitable educational futures (Chen et al., 2020; Douali et al., 2022; George, 2023; Holmes et al., 2019; Lee & Lee, 2020; Pedro et al., 2019; Schank & Edelson, 1990; Williamson & Eynon, 2020)?

RQ2. In what ways does AI reshape cognitive, motivational, and identity-related processes for learners and educators (Antichi et al., 2025; Flanigan, 2025; Heaton & Quan, 2023)?

RQ3. What implications do these transformations hold for institutions, assessment, and the design of equitable educational futures (Antichi et al., 2025; Christensen & Eyring, 2011; Mangione et al., 2025; Selwyn, 2021; Zhai, 2024)?

2. Literature review: Historical trends in psychological disruption of education

2.1. The printing press: Disseminating access, destabilizing gatekeepers

The first significant disruption of educational knowledge systems took place in the 15th century with the introduction of the printing press. Before the advent of print, educational knowledge was organized and mainly circulated through the reproduction and authority of manuscripts, and access to knowledge was consolidated in elites occupying select religious or political institutions. Printing destabilized this living authority over knowledge and its uses, allowing individuals to read and reread texts and interpret them beyond the elite institutions that curated them (Febvre & Martin, 1994; Raven, 2007). This event marked a significant shift toward self-directed literacy, displacing pedagogical authority in oral instruction and locating epistemic authority instead with the rereading and reinterpretation of knowledge in private acts of reading.

Psychologically, the printing press expanded cognitive autonomy because learning was no longer dependent on teachers alone. It also generated new genres of literacy—critical reading, comparison across texts, and private introspection—that revolutionized the nature of

intellectual identity. At the same time, critics worried that a deluge of inaccurate, forgettable, and even heretical material would dilute expertise and destabilize the social order (Bareis & Katzenbach, 2022).

These anxieties parallel current concerns about what AI-generated outputs will do to society. These concerns include the undermining of authority, the spread of misinformation, and the destabilization of expertise. However, just as printing democratized access to texts and required new literacies, AI brings content abundance but demands epistemic vigilance (Coeckelbergh, 2023), places a premium on critical engagement and evolution, and necessitates the redefinition of what counts as trustworthy knowledge and legitimate human authorship.

2.2. Radio and broadcast media

Radio arose as a mass medium with great educational potential in the early 20th century, with public broadcasters (such as the BBC in the UK) and U.S. universities providing localized and remote students with educational programming (Michel, 1987; Sarmah & Lama, 2017; Slotten, 2008). Radio presented a low-cost, asynchronous means for delivering education to marginalized communities left out of formal educational institutions (Damani & Mitchell, 2020; Myers, 2022; Willis, 1994). Psychologically, radio encouraged auditory learning, narrative forms of cognition, and motivational forms of engagement through storytelling, all while generating critical anxieties about the limited, passive, and superficial forms of learning made possible by radio (Slotten, 2008).

Its persistence in the COVID-19 pandemic demonstrates its staying power as a versatile, low-resourced EdTech artifact, especially in cases of disadvantage (Ayanwale et al., 2023; Prahmana et al., 2021). There is an important lesson embedded in this: effective EdTech is not always the most sophisticated, but the most equitable and accessible (Richmond & Christina, 2020; Rodriguez-Segura, 2022). Like AI today, radio was a source of anxiety about attention, engagement, and authenticity, but ultimately expanded access and diversified learning modalities.

2.3. Educational film and television

Film and television inundated classrooms with visual media and reconfigured curricula and pedagogy around multimodal representation (Fuchs et al., 2016). They also introduced demands for visual literacy—requiring students to synchronize verbal and non-verbal information while decoding symbolic, narrative, and visual codes (Stafford, 2010). These audiovisual effects enabled science conceptual learning, situated historical events, and consolidated ethical reasoning and cultural knowledge (Statton Thompson et al., 2022).

For psychologists, film and television did not just expand representational modes; these tools transformed the classroom itself. Teachers shifted from content transmitters to supervisors who managed, interpreted, and extended the materials via film and television (Preston, 2017). Conversely, critics insisted that these tools threatened literacy, fractured attention spans, and fostered passivity or submission (Bates, 2005). Such speeds are evident in today's platformized, AI-generated texts, which likewise risk efficiency at the expense of process, deliberation, and reflection.

Ultimately, film and television exemplify both the promise and peril of educational disruption: new literacies, improved comprehension, and greater engagement, tempered by anxieties about cognitive consequences and the balance between human mediation and machine-delivered content.

2.4. Personal computers (PCs): The digital revolution in learning

The rise of the PCs in the 1970s and 1980s did not simply bring a new machine into the home; it quietly redefined the nature of learning (Cui, 2025). For the first time, individualized, interactive education shifted from an academic ideal to something practical and tangible, on living-room carpets and classroom desks worldwide (George, 2025). This change was driven by the leap from monolithic institutional mainframes to affordable microcomputers such as the Commodore VIC-20, the first machine to sell more than a million units, and the Apple II, which incorporated then-state-of-the-art color graphics and became an emblem of the revolution. Nevertheless, it was not all dry information processing; it was engaging (Railean, 2016). The first kids to study with a computer spent as much time in the colorful, challenge-laden worlds of Reader Rabbit and Math Blaster as they did in the gravity well of the answers themselves (Papert, 2020). The word processor and the spreadsheet quietly revolutionized the basic academic tasks (writing and arithmetic) (Hesse & Scerno, 2009), allowing less time for wrestling with white-out and recopied data and more for ideas and analysis.

The change was profound, logistically and psychologically. We entered a new relationship with these machines, as they became partners in cognition—patient epistemic assistants that provided this magical, instantaneous feedback loop that allowed us to work at our own pace (Pickover, 2024). By collaborating with these machines, we developed new pedagogical habits—we learned to navigate digital spaces, learned the logical structures of coding, and learned the grammar and flow of clicking around interfaces. These literacies rewarded cognitive plasticity, but also sparked a persistent sort of anxiety, the risk that our own skills would start to atrophy, that we would fall into automated ruts of dependence. Would spellcheck ruin our spelling (Flanigan,2025)? Would the calculator atrophy our ability to add and subtract?

The debates dogging the adoption of AI today were first posed even before the age of the PC (Pickover, 2024), with Crevier (1993) writing in his book on the search for AI that AI had blossomed into a ‘thousand flowers’ already, primarily due to the limits of computational memory, which existed at that time.

The computer also transformed our inner lives of desire and purpose. A student was empowered with the capacity to personalize their workspace and pace—an autonomy that enlivened some, but burdened others with cognitive overload. This unveiled a budding digital divide, where unequal access to technology and support at home threatened to deepen existing inequalities. Moreover, the very pace of change was daunting for educators. Teachers embarked on their own journey of adaptation, attempting to integrate the logic of their pedagogical practice with the affordances of these digital tools. Their practice shifted from deeply analog traditions to more digitally mediated forms of instruction, a complicated process often under-supported and under-resourced (Alwaqdani, 2025).

Much like today with artificial intelligence, the early ascent of the PC was a parable of technological ambivalence (Pickover, 2024). It was a cautionary tale of a perennial pendulum, swinging between new promise and new peril, between new advantage for those who had access and new exclusion for those who did not. In these ways, the personal computer was an unmistakable precursor to the legacies we now associate with AI. It was an enabling technology and a disruptive one simultaneously, compounding old inequities with new disparities–a technology for individualized empowerment but also for new modes of inequality (Selwyn et al., 2006). More than anything, it anticipated the enduring psychological dilemma we continue to face: the ongoing and recursive work of metabolizing and revising our self-understanding, sense of competence, and indeed our very ways of thinking concerning the machines we make.

2.5. Internet and cloud-based tools: Decentralization of knowledge and autonomy in learning

The rise of the Internet significantly transformed educational and psychological work, particularly by decentralizing knowledge and destabilizing epistemic authority (Perrotta, 2024; Schmitt, 2019). Learners no longer relied on curated materials provided by teachers or libraries; instead, they were confronted with large, unstructured

environments in which credibility, coherence, and meaning had to be actively assembled. This required new forms of literacy—for example, critical thinking, algorithmic awareness, platform epistemics, epistemic risk management and participatory knowledge practices (Cinque, 2024; Ghantous, 2025; Sudmann, 2019), which in turn reframed the cognitive work of learning in terms of the need for students to assemble fragments of hyperlinked knowledge, while displaying epistemic agility in moving seamlessly across different, and at times competing, systems of knowledge.

Like today's AI, the Internet ushered in not only abundance, but epistemic risk as algorithmic curation and platform design mediated what learners encountered (Dragičević et al., 2022; George, 2024; Tuomi et al., 2023). This generated new pressure for digital discernment and epistemic vigilance in the face of misinformation, manipulation, and polarization (Schmitt, 2021). Students were increasingly expected to curate their epistemic environments, building resilience to "information disorder" and technology bias (Ghantous, 2025; Sudmann, 2019).

Pedagogically, the Internet broke open the spatial and temporal limits of classrooms, provided access to global information networks, facilitated peer-to-peer collaboration, and enabled instructional innovations such as the flipped classroom and blended learning (Noppakhunwong et al., 2024; Pimdee et al., 2024; Pipitgool et al., 2020). These innovations redistributed responsibility from teachers to learners and, while empowering learners, imposed increased demands for motivation, self-regulation, and cognitive load management.

The rise of mobile and cloud technologies in the 2010s extended these developments further, enabling ubiquitous, asynchronous learning across devices and contexts (Agirman & Ercoskun, 2022; Dwiniasih et al., 2024). Smartphones, tablets, and platforms like Google Workspace and Microsoft OneDrive supported distributed cognition and real-time collaboration. However, they also introduced challenges around attention, engagement, and social presence, as learners navigated fluid boundaries between formal and informal learning.

The COVID-19 pandemic normalized mobile/cloud ecosystems, thus normalizing remote learning. The rapid shift to digital and mobile learning venues made device access, bandwidth, and supportive study settings salient forms of inequality (Zovko & Gudlin, 2019). It deepened digital divides, (re-)illustrating how disruption can simultaneously generate new affordances for inclusion and exclusion.

Across these developments, psychological themes emerge: novel literacies displace established competencies, motivation is threatened or transformed, students' cognitive workload increases, and institutional responses lag behind students' adaptations. Together, these precedents illuminate why AI constitutes a psychoeducational, not just a technical, disruption: it amplifies and accelerates human-level disruptions to the cognition and motivation of learners, fundamentally reconfiguring their ability to think, focus, and sustain agency in de-centered knowledge ecologies.

3. Theoretical framing: Interpreting AI's role in psychological change

Understanding AI's impact on education requires a framework that accounts for its systemic, pedagogical, and psychological dimensions. To this end, we draw upon three established perspectives—Disruptive Innovation Theory (DIT), the Technological Pedagogical Content Knowledge framework (TPACK), and Postdigital Education Theory (PET) (Table 1). Each represents a different but complementary angle, where DIT situates AI within historical patterns of disruption, and TPACK highlights how AI reconfigures teachers' professional knowledge. PET emphasizes the blurred boundaries between humans, technology, and culture in the postdigital age.

Disruptive Innovation Theory (DIT), first articulated by Christensen (1997), describes disruptive innovations as those that are initially dismissed as marginal yet come to reshape entire sectors. In educational contexts, DIT emphasizes that AI is not simply "making things more efficient" but is restructuring institutions, learning, and professional responsibility and work (Cain et al., 2024). Framing AI as DIT relieves systemic issues such as institutional inertia and the uneven diffusion of AI.

Technological Pedagogical Content Knowledge (TPACK). TPACK, initially formulated by Mishra and Koehler (2006) and most recently revised by Petko et al. (2025), is a conception of the kinds of knowledge teachers need to integrate new technologies. AI challenges the traditional balance of content, pedagogy, and technology, requiring teachers to extend their expertise to AI literacy (e.g., prompt design, algorithmic awareness, ethical use). TPACK can help explain the specific professional and pedagogical adaptations demanded by AI.

Postdigital Education Theory (PET). PET (Jandrić et al., 2018) moves the claim that digital technologies are not disinterested external objects or auxiliary tools but are inseparable from social and cultural life. PET is relevant for AI since generative systems re-entangle the boundaries between human and machine cognition, provoking questions of authorship, agency, and subjectivity. PET draws attention to the idea that the significance of AI is not only a question of what it does, but how it reinscribes what it means to "know," "learn," and "teach" in the postdigital era.

In sum, these three frameworks provide a multi-level analytic apparatus where DIT helps us conceptualize disruption at the systemic and transhistorical levels, TPACK at the professional and pedagogical levels, and PET at the psychological and cultural levels of identity and self-hood. This triangulated approach allows us to historicize AI, placing it into broader scenarios of innovation and school change, and decomposing it into its more granular implications for cognition, motivation, and affect.

3.1. Disruptive Innovation Theory (DIT): Technology and institutional lag

Christensen's (1997) DIT describes how new technologies begin life on the fringes as either cheaper or more accessible alternatives, before eventually redefining mainstream practice. When thinking about education, it draws attention to the tendency for educational institutions to respond slowly and reluctantly to technological change, seeking to defend established pedagogic conventions and assessment routines in the face of rapid adoption of alternative tools and technologies by learners themselves (Christensen & Eyring, 2011; Selwyn, 2021). The

Table 1
Contributions of DIT, TPACK, and PET in comprehending educational AI.

Framework	Core Focus	Relevance to Education	Psychological Implications	Contribution to this Paper
Disruptive Innovation Theory (DIT) (Cain et al., 2024; Christensen, 1997)	Cycles of historic technological disruption	Explains institutional lag, uneven fronts of adoption, and reorganization of practices	Draws attention to systemic uncertainty, shifting social roles, and pressures to adapt	Situates AI in patterns of historical disruption
TPACK (Mishra & Koehler, 2006; Schmid et al., 2024)	Teacher knowledge at the intersection of content, pedagogy, and technology	Clarifies new demands on teachers' professional knowledge, including AI literacy	Points to metacognitive, motivational, and pedagogical shifts in teacher/learner interactions	Anchors AI in professional practice and classroom strategies
Postdigital Education Theory (PET) (Jandrić et al., 2018)	Human–technology entanglements in education and culture	Frames AI as embedded in sociocultural life, not external to it	Raises questions of agency, identity, authorship, and trust	Explains AI's psychological and cultural significance beyond functionality

case of AI is following these familiar historical patterns, with learners already engaging in vernacular experimentation with ChatGPT for writing, planning, and solving tasks while universities pause to consider detection, authorship, and integrity policy (Mangione et al., 2025; Zhai, 2024).In this way, a psychology of DIT points to the disjuncture between individual and institutional adaptation, where learners' cognitive repertoires can change much faster than the mainstream arrangements built up to assess them (Antichi et al., 2025).

While DIT elucidates institutional resistance and patterns of disruption, some critics argue that it privileges market logics and organizational adaptation over the cultural, psychological, and ethical dimensions of technology use, limiting its explanatory scope for learner experience. Critics of DIT, however, argue that the theory underemphasizes the sociocultural contexts in which disruption occurs—such as cultural attitudes toward authority, structural inequities, and psychological readiness for change—contexts glaringly apparent in the phenomenon of AI adoption, where questions of trust, equity, and identity are central.

3.2. TPACK: The reconfiguration of pedagogical knowledge

Mishra and Koehler's (2006) TPACK framework posits that expert teaching requires an integrated understanding of how content, pedagogy, and technology interrelate. Each significant disruption—from the personal computer to online learning—has forced teachers to reconfigure their expertise, not by abandoning pedagogy or content but by rebalancing their interrelationship (Angeli & Valanides, 2009; Celik, 2023; Voogt et al., 2013). When it comes to AI, this balancing act is even more complicated. Teachers now have to learn how to lead students in the art of:

- prompt formulation and refinement;
- evaluating and revising machine-generated outputs;
- modeling critical engagement with knowledge produced collaboratively by humans and algorithms.

This supports findings in psychology on metacognition and self-regulated learning (Greene, 2017; Zimmerman, 2002). This requires expanding the boundaries of TPACK, which were established in the context of teacher expertise, to construct students' meta-pedagogical literacies in AI-supported learning environments.

Although widely recognized and used, TPACK has been critiqued as being primarily descriptive, not predictive (Brantley-Dias & Ertmer, 2013; Graham, 2011), and for sometimes being overly simplistic in capturing the nuanced, context-dependent decision-making that teachers employ in integrating “disruptive” technologies such as AI (Niess, 2019). Furthermore, TPACK is challenged in accounting for the complexity of adaptive, generative technologies such as AI that “do not simply fall into existing silos of content, pedagogy, and technology” (Reed, 2021, p.239). This finding points to a potential expansion of the theoretical model or a subsequent iteration of the framework that takes up the “emergent literacies” that have arisen or become increasingly relevant in the AI Era, including, for example, prompt design, algorithmic literacy, and critical evaluation of machine-generated content and knowledge.

3.3. Postdigital education theory (PET): Beyond technological novelty

Through PET, Fawns (2019) and Jandrić et al. (2018) argue that technologies are not to be studied as discrete, new, or exceptional objects but are entangled throughout educational life's messy, ongoing, sociocultural practices. PET argues that digital and non-digital, human and machine are increasingly enmeshed. As such, this conceptual framework beckons us to move beyond the tiresome binary of “pro-” versus “anti-” AI, asking instead how AI is already changing the nature of social relationships, of learner identity, and, subsequently, of the psychology of teaching itself (Hervás-Gómez et al., 2024).

Psychologically, PET illuminates AI's significance for cognitive identity and self-concept. If students co-author with ChatGPT, for instance, they might start to question what constitutes their own thinking (Southgate, 2021) or their own learning. PET thus offers a means of articulation between a systemic insight and the lived psychological experience of disruption.

PET offers a compelling lens on hybridity, identity, and meaning-making. However, it remains more conceptual than operational, and its lack of standardized measurement tools can limit its application in empirical studies. Although PET highlights hybridity and identity negotiations, it provides limited methodological tools for translating these insights into measurable constructs. Future research could extend PET by operationalizing psychological dimensions such as cognitive identity shifts or ethical reasoning in AI-mediated learning.

3.4. Synthesis of frameworks

These frameworks offer complementary perspectives on the nature of AI as an educational disruption. DIT addresses why institutional responses to change appear speedy from the expert point of view but slow from the learner standpoint. Indeed, learner practices tend to lead systems, which generate tensions concerning legitimacy, assessment, and uptake (Christensen et al., 2016; Cristofaro & Giardino, 2025).

TPACK situates disruption at the pedagogical level, showing how teachers must rebalance content, pedagogy, and technology to enable meaningful learning in AI-infused environments. In contrast, Postdigital Education Theory (PET) views disruption at the psychological and identity level, highlighting how learners and teachers renegotiate authorship, agency, and even the meaning of “knowing” in human–machine ecologies.

Bringing these perspectives into dialogue shows that what matters about AI is not simply its novelty as a technical tool, but its disruptive significance in affecting educational institutions, teaching practices, and learner identity in layered ways. The following synthesis (Table 2) situates DIT, TPACK, and PET alongside each other to clarify how each framework addresses institutional, pedagogical, and psychological dimensions of disruption—and thereby offers a more layered foundation for analysis of the place of AI in education.

In line with Jandrić's (2018) notion of *postdigital openness* as an “intellectual commons,” the postdigital perspective foregrounds how human and machinic entanglements reshape learner agency in ways that cannot be fully captured by linear models of disruption. Where DIT emphasizes rupture and institutional lag, postdigital thought insists that technologies are already woven into the “messy” and blurred boundaries of everyday learning identities (Jandrić, 2018). This underscores the need to conceptualize learner subjectivity as situated within complex sociotechnical assemblages rather than as a stable category merely acted upon by disruption.

As Selwyn et al. (2020) argue, machines are increasingly capable of learning human habits and influencing choices in unprecedented ways, thereby challenging accepted definitions of meaningful knowledge. This reinforces the concern that learners risk being positioned as datafied objects within AI-driven educational systems. By contrast, Facer & Selwyn, 2021 remind us that learning is fundamentally relational, requiring encounters with others and engagement with difference. Taken together, these perspectives underscore the need to conceptualize learner subjectivity as contested terrain—oscillating between the individualizing logics of disruption and the communal, identity-oriented stance of postdigital thought.

The comparison highlights three distinct yet overlapping dimensions of disruption. At the institutional level, DIT shows how AI challenges established norms but is mediated by inertia, policy lag, and uneven diffusion. At the pedagogical level, TPACK underscores that effective use of AI is not automatic; it requires deliberate redesign of teaching knowledge that aligns content expertise, pedagogy, and tool

Table 2
Theoretical frameworks for interpreting AI's role in educational disruption.

Framework	Core Concepts	Application of AI in Education	Psychological / Pedagogical Relevance
Disruptive Innovation Theory (DIT) (Christensen, 1997; Lile et al., 2025); Jandrić (2018); McCausland (2023); Päväloaia and Necula (2023); Yadav (2019).	- Disruptions begin at the margins before overtaking incumbents. - Institutions adapt slowly compared to learner adoption.	- AI tools like ChatGPT spread quickly through informal student use before formal institutional integration. - Creates tension between existing assessment models and AI-enhanced learning.	- Explains resistance from schools/ universities. - Highlights institutional lag and anxiety about legitimacy and authorship.
Technological Pedagogical Content Knowledge (TPACK) Mishra and Koehler (2006).	- Effective teaching requires alignment of technology, pedagogy, and content. - Teachers must integrate technology without sacrificing conceptual integrity.	- Educators need new professional literacies (e.g., prompt engineering, critical evaluation of AI outputs). - Balances AI use with disciplinary rigor.	- Connects to metacognition and self-regulated learning. - Shows how teachers scaffold students' reflective AI use.
Postdigital Education Theory (PET); An and Oliver (2021); Fawns, 2019; Hayes et al. (2024); Jandrić et al., 2018; Latour and Venn (2002); Säljö (2010); Selwyn (2021)	- Digital is no longer "new" but entangled with everyday life. - Focus on hybridity, identity, and meaning-making. - Challenges the view of technology as a neutral tool; focuses on the ontological and relational aspects of human-education-technology entanglements.	- AI is part of messy human–machine ecologies. - Shifts what it means to "author," "know," and "learn."	- Centers cognitive identity and self-perception. - Illuminates how students redefine knowledge, agency, and authenticity in AI contexts.
Critical Sociology of EdTech (Facer and Selwyn (2021); Miller, 2021; Selwyn, 2021)	Technology is not neutral; its implementation is shaped by and can exacerbate existing social, economic, and racial inequalities.	AI tools risk reinforcing bias in assessments and content; access to advanced AI creates new digital divides.	Highlights fairness, justice, and equal opportunity; connects to student and community well-being.

Table 3
Psychological constructs across historical educational disruptions.

Historical Disruption	Core Psychological Themes	Illustrative References
All Technological Disruptions (Meta-Theory)	Moral and ethical negotiation of new human-technology hybrids; technology's "ends of means" generating unforeseen consequences.	Kranzberg (1986); Latour and Venn (2002); Lile et al. (2025); Lind (2025).
Printing Press	Emergence of *self-directed literacy*; shift in *cognitive authority* from teacher to learner; anxieties over misinformation and overload	Febvre and Martin (1994); Li (2023); Raven (2007); Bareis and Katzenbach (2022)
Radio & Broadcast Media	*Attention modulation* through auditory learning; *narrative cognition*; increased *access and motivation* for marginalized learners; concerns over *passive reception*	Ayanwale et al. (2023); Damani and Mitchell (2020); Prahmana et al. (2021); Slotten (2008); Willis (1994)
Film & Television	Development of *visual literacy* and multimodal comprehension; teacher role shifting to *facilitator*; anxieties over shortened *attention spans* and reduced *reading depth*	Bates (2005); Preston (2017); Stafford (2010); Statton Thompson et al. (2022)
Personal Computers	Rise of *digital literacies* and *computational thinking* (word processing, coding, problem-solving); enhanced *individual agency* and *self-directed exploration*; debates over *skill loss* vs. *personalization*	Aithal and Maiya (2023); Ito (2012); Säljö (2010); Wing (2006).
Internet & Cloud Tools	*Critical evaluation* of sources; *epistemic vigilance* against misinformation; *cognitive load management* in hyperlinked environments; enhanced *autonomy and collaboration*; motivational challenges in self-regulated learning; Recognition of the hybrid, distributed nature of knowing and cognition	Cinque (2024); Dragičević et al. (2022); Ghantous (2025); Säljö (2010); Schmitt (2019, 2021); Tuomi et al. (2023).
Mobile & Cloud Ecosystems (2010s–COVID)	Expansion of *ubiquitous learning*; *distributed cognition*; tension between *flexibility* and *distraction*; reinforcement of *digital divides* and equity concerns	Agirman and Ercoskun (2022); Dwiniasih et al. (2024); Säljö (2010); Zovko and Gudlin (2019).
Artificial Intelligence (Current)	Need for *algorithmic and prompt literacy*; redefinition of *authorship* and *cognitive identity*; *ethical reasoning* around fairness and bias; demand for *agency and resilience* in AI-mediated learning.	An et al. (2025); Mangione et al. (2025); Raja et al. (2024); Zhang et al. (2025).

affordances. At the psychological level, PET foregrounds what is often underexamined: how learners and educators renegotiate their sense of authorship, agency, and cognitive identity concerning machine-generated knowledge.

While Table 1 synthesizes theoretical frameworks to situate AI within broader educational disruption, it is equally important to ground these ideas in the historical record of past technologies. The literature shows that every disruption introduced recurring psychological themes—new literacies, altered motivational dynamics, cognitive load management, and shifting identities—that both empowered and challenged learners. Table 3 distills the psychological constructs across major historical disruptions (from print to AI) to clarify these connections. This synthesis addresses the concern of fragmented treatment and highlights continuities that clarify why AI's disruption must be understood as cognitive and psychological as much as institutional or pedagogical.

Together, these frameworks clarify that AI is not merely a technological asset to be added to classrooms, but a phenomenon that necessitates reorganization across systems, practices, and identities. Crucially, they imply that sustainable integration will hinge less on the technical sophistication of AI than on the capacity for institutions, teachers, and students to make meaningful changes in how they take up their evolving roles. Importantly, this layered view also foregrounds the core psychological focus of this paper: AI's capacity to destabilize assumptions about what it means to know, teach, and learn.

4. Strategic psychological implications for educators, learners, and institutions

To put the change from content delivery to metacognitive engagement into practice in AI-mediated learning environments, instructors can employ strategies that intentionally make students' thinking visible and deliberate. Teachers might scaffold students' critical evaluations of

AI outputs by comparing machine-generated responses with human-written texts and asking them to justify strengths and weaknesses. Reflective writing prompts can encourage them to document how AI influenced their reasoning. In contrast, collaborative projects juxtaposing human and machine reasoning can help students recognize where AI augments or limits deep understanding. Finally, instructors can explicitly teach new AI literacies that enable learners to control, collaborate with, and critically assess AI in educational contexts. These strategies are consistent with established models of self-regulated learning (Zimmerman, 2002) and metacognitive scaffolding in educational practice (Greene, 2017), while taking into account the new ways that AI alters learners' agency and cognitive identity in education (Table 4). In particular, emerging digital literacy frameworks guide teaching knowledge and skills needed to function in generative AI-enriched environments, such as prompt writing, algorithmic awareness, and ethical reflection.

4.1. Educators: Redefining instruction through cognitive scaffolding

As Luckin et al. (2022) stress, empowering educators to be 'AI-ready' requires moving beyond technical familiarity to contextualized, participatory training. In our vignettes, teachers are positioned not as passive users of AI tools but as active mediators of students' epistemic and emotional engagement. AI accelerates the shift away from teachers as content providers to teachers as metacognitive engagement facilitators. Teachers become the facilitators of students' self-regulation and critical inquiry, enabling students to meaningfully engage with AI-curated knowledge (Luckin et al., 2022; Umar et al., 2025). This also involves equipping teachers to teach prompt literacies (Ng et al., 2021), recognize when students are outsourcing vs augmenting cognition, and using AI to complement iterative engagement with learning processes and products rather than shortcutting thinking. Their professional learning design should also address educators' emotional and cognitive responses as they navigate disruption, including cognitive dissonance, loss of teacher identity, and fears of eroded pedagogical authority (Treacy & Leavy, 2023; Zhai, 2024). To move beyond abstraction, it is helpful to illustrate how "prompt literacy" and "AI-based iterative learning" might unfold in specific classrooms.

4.1.1. Vignette 1 (undergraduate history seminar)

Students are tasked with drafting a short essay on the causes of the French Revolution. The instructor first models a poorly structured prompt to ChatGPT and shows its superficial response (Aristy-Reyes, 2024). The class then co-constructs a more refined prompt, generating a nuanced answer. Students critically compare AI outputs with primary source excerpts, annotating both strengths (breadth, connections) and weaknesses (anachronism, lack of source attribution) (Sun, 2024). This staged process operationalizes *prompt literacy* and *epistemic vigilance* while keeping human judgment central.

Rice (2025) also noted that ChatGPT enhanced the student productivity of 57 history essays in a college history course to encourage student learning and critical thinking. Second, that it was warned that educators must impart to their students the significant limitations of generative AI's knowledge-production abilities, as algorithms trained on LLMs reproduce historic inequalities.

4.1.2. Vignette 2 (STEM problem-solving workshop)

In an engineering design course, learners use AI to generate alternative solutions to a structural challenge (Rane, 2023) and the design and development of up-to-date content (Yelamarthi et al., 2024). Working in groups, they iteratively refine both the prompt and their design, documenting how AI suggestions influenced their reasoning (Liu & Sun, 2025). The final task requires them to justify which AI contributions were retained, modified, or discarded. This practice embeds *AI-based iterative learning* into a cycle of design–reflection–revision, balancing efficiency with cognitive ownership assemblages rather than as a stable category merely acted upon by disruption.

Such iterative refinement mirrors Zimmerman's (Zimmerman & Moylan, 2009) cyclical model of self-regulated learning, in which forethought, performance, and self-reflection stages recursively inform one another. Here, AI-based feedback becomes a catalyst for metacognitive monitoring and motivational control, reinforcing students' capacity to regulate their own learning.

4.1.3. Vignette 3 (secondary language arts)

Students use AI to co-write a short story (Ghajargar et al., 2022). In each round, the AI generates one paragraph, and students respond with their own continuation. The teacher scaffolds reflection by asking: *What choices did you accept, reject, or modify? Why?* The iterative process encourages learners to see themselves as authors in dialogue with AI, developing *cognitive autonomy* and *identity ownership* in hybrid authorship (Susha et al., 2024).

These vignettes illustrate how abstract constructs translate into situated pedagogical practice, offering instructors a repertoire of task designs that cultivate both technical fluency and reflective agency.

These situational illustrations also resonate with Jandrić's (2018) framing of postdigital openness as an "intellectual commons," where education becomes a shared praxis of co-existence between humans and intelligent technologies. For example, when students co-construct prompts in the history seminar vignette, they participate in precisely this kind of commons: an open, negotiated space where human judgment and AI output are brought into dialogue. Such practices not only operationalize prompt literacy but also instantiate the postdigital principle that openness is at once a pedagogical method and a social responsibility (Maidee, 2025). In line with Jandrić's (2018) framing of postdigital openness as an 'intellectual commons,' the postdigital perspective emphasizes that subjectivity is continually renegotiated through entanglements of human and machinic actors, rather than determined by disruption alone.

4.1.4. Vignette 4 (Japanese medical education)

In a Japanese medical education setting, ChatGPT-4 has been trialed

Table 4
Operational strategies for educators to foster metacognition, AI literacy, and self-regulation.

Teaching Focus	Operational Strategy / Example	Targeted Literacy or Skill	Developmental Sequence
Critical Evaluation of AI Outputs	Assign tasks where students compare AI-generated responses to scholarly texts, noting strengths/weaknesses.	Critical evaluation, epistemic vigilance	Entry-level skill; foundation for reflective use of AI
Reflective Metacognition	Use reflective journals/logs for students to describe how AI shaped their reasoning.	Metacognitive monitoring, self-awareness	Builds on evaluation; encourages internal regulation
Collaborative Human–AI Comparison	Group projects contrasting human and AI solutions to the same problem	Agency, collaborative reasoning, ethical reflection	Intermediate: combines evaluation with social/ethical perspectives
Prompt Design & Iteration	Scaffold exercises where learners iteratively refine AI prompts to improve outputs	Prompt literacy, iterative problem-solving	Builds technical literacy alongside reflective practice
Ethical & Algorithmic Awareness	Class debates or case studies on bias, fairness, or misuse of AI	Ethical reasoning, algorithmic literacy	Higher-level integration of social and cognitive dimensions
Balancing AI & Autonomy	Design assignments requiring partial AI use alongside independent work (e.g., AI-drafted outline + student-authored analysis)	Self-regulation, autonomy, transfer of learning	Advanced stage: integrates autonomy with critical, ethical AI use

in generating clinical vignettes in the local language, with physicians evaluating both accuracy and educational usefulness (Takahashi et al., 2024). Students can be assigned AI-generated cases to analyze, critique, and refine collaboratively with peers and instructors. This process foregrounds prompt literacy (in shaping AI case queries), iterative learning (through cycles of critique and revision), and epistemic vigilance (in checking AI outputs against medical knowledge). Such designs illustrate how AI can supplement clinical reasoning training while reinforcing the need for human oversight, echoing recent studies showing ChatGPT's potential on medical wards as a cognitive aid for decision-making and reflective discussion (Skryd & Lawrence, 2024).

4.2. Learners: Developing AI-responsive literacies and self-regulation

These situational illustrations are also consistent with Facer and Selwyn's (2021) discussion of individualized, automated systems, which rather than isolating learners, prompt literacy and co-authorship practices invite collective negotiation and teacher–student collaboration. This operationalization highlights Jandrić's (2018) ideas on postdigital commons, where meaning is co-constructed in shared human–AI encounters.

Moreover, as students increasingly find themselves in learning environments where LLMs act as helpers and thinking partners. Success in such environments requires not only technical proficiency in interacting with these new cognitive partners, but also an evolving set of literacies that develop progressively over time. Cognitive autonomy, epistemic vigilance, metacognitive regulation, and ethical reasoning should not be treated as a checklist of discrete skills; rather, they constitute a developmental trajectory in which early capacities scaffold later ones. Without structured support, students may over-rely on AI tools and fail to cultivate higher-order critical and reflective thinking (Barrios Sánchez & Carazas Durand, 2025).

Table 5 synthesizes these insights by mapping concrete instructional strategies onto a developmental sequence of AI-resilient literacies, providing educators with both a theoretical rationale and a practical guide for staged classroom implementation.

Table 5
Instructional strategies for fostering AI-resilient literacies.

Stage & Focus	Operational Strategy / Example	Targeted Literacy or Skill	Developmental Progression
1. Cognitive Autonomy (Foundation)	Low-stakes assignments where students choose whether to use AI (e.g., outline drafting vs. manual revision)	Agency, ownership, motivation	Entry-level: establishes independence, resists passive dependence
2. Epistemic Vigilance (Entry-Level Criticality)	Structured tasks comparing AI outputs with scholarly texts or databases	Critical evaluation, skepticism	Builds on autonomy by cultivating discernment and reliability checking
3. Metacognitive Regulation (Reflective Use)	Reflective journals/logs; think-aloud protocols on when/why AI was used	Metacognitive monitoring, conditional strategy use	Builds on vigilance; strengthens internal regulation of tool use
4. Collaborative Human–AI Comparison (Intermediate Integration)	Group projects where students contrast human vs. AI solutions	Collaborative reasoning, ethical awareness	Combines earlier skills with social/ethical negotiation
5. Ethical & Algorithmic Awareness (Advanced Literacy)	Debates, case studies, or role-play on AI bias and fairness	Ethical reasoning, algorithmic literacy	Higher-level synthesis of social + cognitive dimensions

This framework places learners' progression on a spectrum: autonomy as its anchor, vigilance as its expansion of discernment, and metacognitive regulation as its reflective application, and only then are students attending to collaborative, ethical, and transfer-oriented practices. Importantly, this order frames AI not as a "shortcut," but as a prompt for layered skills development.

Cross-references to the theoretical frameworks in Section 3 underscore this reading. The TPACK model situates teachers' scaffolding efforts for each phase as balancing content, pedagogy, and the kinds of AI tools and uses that maintain the integrity of what makes any discipline distinct. PET adds another layer by highlighting how generative literacies are entangled with identity, agency/confidence, and epistemic trust within hybrid human–machine ecologies. DIT helps explain why learners tend to acquire these literacies ahead of changes in institutional policies, and subsequent lay-adoptions of innovation would be idiosyncratic, patchy, and shallow without structured interventions. Together, this developmental framework and its cross-framework grounding offer a guide for educators to structure plans for teaching that build metacognition and resilience alongside making meaningful adaptations for AI-enhanced learning contexts.

4.3. Institutions: Cultivating psychological safety and equitable transformation

Institutions must move beyond compliance considerations toward innovation cultures that are both ethical and psychologically sustainable for learning. These concerns range from new forms of emotional labor, assignment design, and psychological "cost" of navigating ambiguous norms (Mintii & Semerikov, 2024; An et al., 2025). They further involve the responsibilities of transparent, trust-informed AI policies that integrate psychological and educational research, equitable infrastructures that guarantee all learners have access (Zovko & Gudlin, 2019), and adaptive curricula that normalize AI for learning with a focus on student identity and cognition. Institutions that fail to act against these strategies threaten to exacerbate inequalities in skill development and reduce trust in AI-mediated education.

4.4. Cognitive identity and AI-mediated self-perception: Psychological frameworks

The influence of generative AI in education extends beyond pedagogical efficiency, striking at the heart of learners' psychological self-conceptions as autonomous knowers and thinkers (Hayes et al., 2024). While past technological shifts—such as the advent of the printing press or personal computers—challenged centralized knowledge authority, generative AI introduces a qualitatively different disruption. By simulating human-like cognition, it destabilizes the internal architecture of cognitive self-hood. This section explores how these developments can be interpreted through several psychological frameworks, illuminating the evolving relationship between learners and their intellectual identities.

4.4.1. Reframing cognitive agency

Recent research indicates that interactions with generative AI prompt existential reflections about the nature of thought and knowledge as users confront machines that can perform ostensibly human cognitive tasks (Fehér & Katona, 2023). Such experiences blur the traditional boundary between internal cognition and externalized expression, raising novel challenges for educational identity formation.

Self-Determination Theory (SDT) is especially instructive here. It posits that identity and motivation are structured through three interrelated needs: competence, autonomy, and relatedness (Deci & Ryan, 2012). By excelling in knowledge production, AI systems paradoxically compromise learner autonomy—even as they scaffold competence. This tension explains why learners initially benefit from AI-supported tools

(e.g., intelligent tutors or 'study buddies'). However, it may later exhibit motivational decline or dependency when such tools replace rather than support self-directed thought (Jose et al., 2025). In this case, the autonomy-competence dilemma becomes central to understanding AI's psychological effects.

Drawing on SDT (Ryan & Deci, 2020), we argue that learner agency is best understood in terms of the conditions under which autonomy, competence, and relatedness are supported or undermined in AI-mediated environments. This provides a motivational bridge between system-level disruption and identity-focused analyses.

4.4.2. Metacognitive identity models

Flavell's foundational work on metacognition distinguishes between 'knowledge of cognition,' awareness of learning strategies, and 'regulation of cognition,' which involves planning, monitoring, and evaluating learning processes (Meher et al., 2021). Generative AI affects both dimensions. On the one hand, students interacting with tools like ChatGPT often show improved strategy awareness, developing meta-skills such as prompt engineering. On the other hand, they frequently exhibit diminished regulation capacities, particularly in planning and independently navigating learning pathways.

Schraw and Dennison's (1994) Metacognitive Awareness Inventory (MAI) suggests that overreliance on AI correlates with reduced conditional knowledge—learners struggle to determine when and why to apply particular strategies without AI mediation (Schraw & Dennison, 1994). Longitudinal qualitative data from student interviews support this: many report confusion about whether academic "knowing" now consists of internalized understanding or the ability to generate effective prompts.

4.4.3. Identity construction through cognitive boundaries

Insights from self-concept theory help explain how AI technologies reshape learners' identity formation (Jose et al., 2025). As students increasingly outsource cognitive labor to machines, their academic identity shifts from that of *originators* of knowledge toward *orchestrators* who manage and coordinate outputs (Shum & Luckin, 2019). This process is closely tied to epistemic distancing, where learners cease to view themselves as the primary authors of their work, raising questions about authorship and responsibility (Selwyn, 2021; Yan et al., 2025). From a symbolic interactionist perspective, identity is co-constructed through the roles that tools play in meaning-making, and AI has emerged as a powerful actor in this negotiation (Schulz (2023); Knox, 2020). In this sense, AI functions as a cognitive mirror, refracting and amplifying learners' self-concept, sometimes reinforcing feelings of inadequacy, displacement, or dependence (Nopas, 2025).

4.4.4. Developmental psychology perspectives

Though not commonly cited in empirical research on AI in education, Erikson's psycho-social stages offer a generative framework for understanding patterns researchers have observed in their studies regarding heavy involvement in or alienation from AI tools. The crisis of identity vs. role confusion—located in adolescence/early 20s—can be mapped onto the ambivalence with which many students seem to engage with AI tools (Gross, 2020). For example, authorship ambiguities and uncertainty over intellectual ownership can manifest the unresolved tension between active identity formation and external mediation (Jose et al., 2025; McCreary, 2014). Antichi et al. (2025) build upon and extend this observation by highlighting how deeply immersive technologies, such as AI and virtual reality tools that mimic affective or embodied cognition, intensify the tensions inherent to this developmental crisis. To the extent that learners perceive their neural and affective processes of meaning-making as distributed across systems, the challenge of knitting together a coherent sense of themselves as intellectually capable becomes even harder to achieve.

4.4.5. From cognitive paradox to educational readiness

The psychological frameworks explored in this section all point to a profound paradox: AI helps us to learn by reducing extraneous cognitive load but reduces germane load required for sense making and identity construction (Jose et al., 2025). This engenders a metacognitive tension where technologies that aim to reduce the friction of learning, if taken at face value, risk crowding out the cognitive labor necessary to construct a coherent intellectual identity.

Resolving this paradox depends upon a shift in stance from considering AI only as an aid to instruction to engaging with AI as a co-shaper of cognition. Thus, educational responses must foreground three interwoven priorities. First, preserving agency entails designing AI-mediated tasks that elicit metacognitive awareness, creating task-based "productive friction" (Mazari, 2025) that invites learners to sharpen their sense of where their cognition ends and the system's begins. Second, reclaiming authorship requires pedagogical frameworks that situate AI as a co-constructor rather than a primary generator of knowledge, asserting learners' epistemic ownership over and against the machinic contributions of generative systems. Third, cultivating epistemic confidence involves purposeful spaces for learners to probe the seam between mind and machine– structured rituals for reflecting on, interrogating, and restoring a sense of authority and interiority to knowledge claims (Gomez & Lee, 2015; Yaacoub et al., 2025).

At its core, this reconceptualization suggests that AI does not substitute for thinking but redefines the conditions of possibility for thinking. The task of education is to ground learner identity in those capacities that remain irreducibly human: the capacity to tolerate ambiguity, to engage in ethical deliberation, and to sustain interrogative curiosity (Bearman et al., 2023). Instead of opposing AI as a threat or embracing it as a solution, educators and institutions must develop psychological readiness—a mosaic of emotional literacy, cognitive adaptability, and ethical reflexivity (Douali et al., 2022; Ghiasi, 2024; Hayes et al., 2024). Rather than a cognitive tool, AI becomes an identity catalyst, inviting learners and educators into a renovated conversation about what it means to think, know, and learn in an era of intelligent machines.

The questions that arise now are not technical but existential:

- How do we cultivate authentic self-hood in distributed cognitive environments?
- What stories of intellectual identity are available to us after machines become co-writers of our thoughts?

Such questions are not peripheral anymore; they define the next phase of education's evolution.

5. Conclusions and perspectives: Harnessing the ways forward

The history of educational disruption is extensive, but no two forms of disruption have been alike. The printing press distributed literacy and dispersed epistemic authority, radio transmitted instruction across borders, film and television introduced new literacies of representation, personal computing individualized learning, and mobile/cloud technologies collapsed space and time. By contrast, artificial intelligence (AI) does not just deliver information—it deliberates in it, improvises, and gets entangled in making meaning itself.

Our analysis locates AI in this genealogy, clarifying three intersecting layers. AI historically echoes earlier disruptions by reproducing institutional lag, pedagogical redesign, and redefinition of literacy. Pedagogically, AI demands a recalibration of content, pedagogy, and technology (TPACK) toward metacognition, critical evaluation, and self-regulation. Psychologically, it unsettles learner identity by reframing authorship, agency, and cognitive autonomy. In this manner, AI's transformative significance lies not only in its technical capacity but also in the power to reshape what it means to know, learn, and teach.

At the same time, this study is limited by its conceptual and

framework-driven orientation. While it provides direction on patterns and theoretical understandings, it does not offer empirical evidence, and the selected reliance on specific theories (DIT, TPACK, PET) is illustrative rather than exhaustive. Further research in classrooms is needed to test and supplement its claims.

Finally, the revised manuscript contributes by (a) synthesizing theoretical frameworks dialectically to foreground contestation and complementarity, and (b) providing fine-grained pedagogical vignettes, across multiple disciplines, that operationalize emerging literacies for educators and learners.

5.1. Practical implications

The findings offer tangible implications for practice. Educators must reconceptualize their roles away from being predominantly conduits of knowledge toward facilitating metacognitive engagement, and embed activities that foster prompt literacy, critical engagement with AI outputs, reflective metacognition, and ethical reasoning. Learners acquire AI-responsive literacies in successive phases (i.e., cognitive autonomy, epistemic vigilance, metacognitive regulation, ethical and self-regulated use). At the same time, institutions must ensure AI accessibility, clear guidelines for authorship and assessment, and psychological safety and innovation. In all these ways, stakeholders can move from reactive accommodation to intentional adaptation — treating AI not merely as a threat to be managed but as an occasion to re-envision education.

6. Limits

The purpose of this study is conceptual and historical. As such, the use of analogy and theory bears the risk of oversimplifying the intricacies of AI or missing out on emergent dynamics. The specific theoretical choices of DIT, TPACK, and PET reflect a specific vantage point while not addressing the full breadth of paradigms through which educational impacts of AI might be interpreted. Moreover, the focus here is mainly on higher education, and generalizability to other learning contexts, such as K–12 or vocational education, might be limited. These boundaries should be kept in mind and are a reminder of the potential value of empirical corroboration.

7. Directions for future research

Building on these limitations, future work should pivot to empirical research to gather evidence of how AI reshapes cognition, motivation, and identity across settings. Several areas appear especially fruitful. More research is needed on how learners interpret the novelty of AI compared to previous tools, and how these interpretations inform their willingness to accept it as a legitimate cognitive partner. Studies should address the territory of metacognition and self-regulation, especially whether students build or lose reflective monitoring skills in response to AI. Motivation and autonomy are ripe for longitudinal studies, since AI appears to encourage epistemic play in some cases and to undercut self-efficacy in others. Ethical reasoning and epistemic vigilance should be investigated systematically, including questions of academic integrity and learners' trust in AI-generated ideas. Institutional trust and policy coherence present another rich field, since student confidence in their deployed strategies depends on explicit guidance about legitimate and illegitimate AI use. Furthermore, the most profound questions concern cognitive identity: what it means to author, think, and be an epistemic agent in entanglement with a machine.

Taken together, these directives point to the need for a range of methods—including case study, survey, interview, experimental, and cross-cultural and longitudinal research designs—to understand how AI's psychological, pedagogical, and institutional implications in education are gradually changing. Shifting the focus from conceptual reflection to empirical evidence can also enable the field to develop corresponding frameworks and instruments to measure such changes confidently.

CRediT authorship contribution statement

Triyuth Promsiri: Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Software, Resources, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization.

Ethical approval statement

N/A.

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