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Generative AI and Critical Thinking: A Challenge for Cognitive Development

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Abstract: The article investigates how generative AI technologies threaten to reshape, and potentially erode, the cognitive foundations of critical thinking. While digital tools increasingly mediate learning, reflection, and communication, their capacity to generate fluent text risks displacing essential practices—such as argumentative writing and handwriting—that are foundational for the development of analytical and independent reasoning. Drawing on cognitive science, philosophy of education, and recent empirical studies, we argue that generative AI facilitates a form of cognitive outsourcing that undermines epistemic engagement and reflective effort. The article offers a dual-level analysis: on one hand, it shows how writing practices constitute thought rather than merely express it; on the other, it explores how LLMs may bypass the deliberative and justificatory processes essential to critical autonomy. We also review emerging pedagogical strategies aimed at integrating AI tools without compromising cognitive growth, and we conclude with a normative call to protect the conditions—both technological and educational—under which critical thinking can survive. The article thus contributes to an urgent philosophical debate: whether the widespread adoption of generative AI is compatible with the preservation of intellectual self-determination in democratic societies.

Keywords: epistemic outsourcing; cognitive offloading; cognitive deskilling; intellectual autonomy; educational ethics; material engagement

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1. Introduction: Cognitive shifts in the digital era

Over the past 10 to 15 years, several studies have documented a potential decline in key cognitive abilities—particularly reasoning, critical thinking, and reflective judgment—amid the increasing saturation of digital technologies in everyday life (van Dijk, 2006). This trend has been referred to as the "reverse Flynn effect" (Bratsberg and Rogeberg, 2018), where the Flynn effect refers to the observed substantial and long-term increase in "fluid" intelligence test scores (especially IQ scores, which assess problem-solving and reasoning) over time, across many countries and populations during the 20th century.[1]

Today, digital multitasking, cognitive offloading, and overreliance on algorithmic tools such as generative AI appear to coincide with a decrease specifically in fluid intelligence.

[1] While these trends are suggestive, it is important to note that the available evidence remains largely correlational. The observed associations between digital exposure and cognitive changes may partly reflect pre-existing differences in cognitive styles or learning habits. Accordingly, the present analysis should be understood as advancing a theoretically grounded and empirically informed hypothesis, rather than establishing a definitive causal claim.

While the issue of causality remains contested—as this may merely reflect a temporal correlation—converging evidence suggests that constant exposure to fragmented information, passive consumption, and reduced cognitive effort may undermine critical thinking (Firth et al., 2019; Müller et al., 2021; Shin et al., 2024). Thus far, this particular risk has received limited scholarly attention, whereas greater focus has been placed on the impact of digital devices on interpersonal relationships and mental health (Haidt, 2024).

If it is true that cognitive abilities are destined not only to be partially eroded but at the very least reshaped by the digital environments in which we now live, then educational environments face the urgent task of developing pedagogies that strengthen analytical rigor and foster epistemic autonomy in a world increasingly saturated with information and shaped by AI mediation, which may also give rise to misinformation and disinformation.

Critical thinking skills—understood as the capacity to construct, evaluate, and articulate well-founded arguments—are widely recognized as a cornerstone of higher education and a prerequisite for responsible citizenship and informed professional practice—as these involve rationality, clarity, capacity of analysis, and independence of thought. As Ennis (1989) defined it, critical thinking involves "reasonable reflective thinking focused on deciding what to believe or do," integrating both cognitive skills and intellectual dispositions. These include logical reasoning, the ability to assess evidence and claims, the openness to multiple and often conflicting perspectives, and the capacity to detect fallacies and refine one's own arguments through structured analysis (Facione, 1990; Haber, 2020).

In pedagogical terms, critical thinking serves as a bridge between content acquisition and epistemic maturity. Paul and Elder (2011) emphasize its self-directed and self-corrective nature, framing it as a disciplined process of assessing the elements of thought and improving them through fair-minded, intellectual engagement. Halpern (2013) adds that critical thinking is not a generic skill but a teachable and domain-sensitive competence that enhances the learner's ability to make reasoned decisions and avoid cognitive pitfalls.

Developing these skills is not just an educational objective. Rather, it is a practical response to the cognitive and cultural challenges of our time, such as information overload, algorithm-driven content curation, and growing uncertainty about what can be trusted. Critical thinking equips individuals to think independently, make informed and responsible judgments, and defend their views with reasoned arguments. These abilities are crucial for engaging in the complex and often conflicting streams of information that shape today's knowledge landscape.

2. Digital challenges to traditional ways to foster critical thinking

Many educational strategies and tools have been proposed and are being used to support the development of critical thinking and fluid intelligence. In this article, we focus specifically on argumentative writing and handwriting, two practices that appear especially vulnerable to the transformative impact of digital technologies, and generative AI in particular.

As to argumentative writing, research has demonstrated that it can effectively enhance critical thinking skills. Argumentative writing is not just a pedagogical technique—it is a cognitive scaffold for epistemic autonomy. It indeed functions as a powerful tool for cultivating critical thinking by requiring individuals to articulate positions, construct logically coherent arguments, and engage with evidence in a structured and reflective manner (Ferretti and Graham, 2019; Coirier et al., 1999; Hartwell and Aull, 2022). Unlike oral discussion, which may privilege spontaneity, written argumentation necessitates sustained cognitive effort, clarity of expression, and a heightened awareness of logical structure and rhetorical strategy.

There appears to be a close relationship between critical thinking and the ability to justify one's beliefs through reasoned discourse. In this sense, argumentative writing provides a concrete domain in which critical thinking is both exercised and made visible. It fosters the capacity not only to formulate claims and support them with appropriate evidence, but also to anticipate counterarguments, weigh alternatives, and revise one's reasoning in light of new considerations—hallmarks of what Paul and Elder (2011) define as self-directed, self-corrective thinking.

In addition, the very process of writing has been shown to promote metacognition, as writers must monitor their own reasoning, identify inconsistencies, and refine their arguments to achieve coherence and persuasiveness (Halpern, 2013). Writing does not merely communicate thought; it becomes a mode of thinking itself, shaping and extending cognitive processes through the affordances of the written medium. This aligns with broader cognitive theories of writing as a form of externalized reasoning (Scardamalia & Bereiter, 1987), where the act of putting ideas into words can lead to their clarification, evaluation, and transformation.

This claim can be further clarified by noting that argumentative writing externalizes intermediate steps of reasoning that would otherwise remain implicit or unstable. By making premises, inferential connections, and conclusions explicit, writing allows for a form of cognitive inspection that is difficult to achieve in purely internal deliberation. In this sense, writing not only supports but stabilizes complex reasoning processes, enabling revision, error detection, and the progressive refinement of ideas. The cognitive value of argumentative writing thus lies precisely in its capacity to make thinking visible, manipulable, and corrigible over time.

Handwriting, in particular, can also improve critical thinking skills, hence its erosion signals a broader shift away from embodied reasoning. Handwriting—especially in its slow, reflective form—exemplifies how cognition is materially enacted. It is a materially grounded cognitive practice through which thought is not merely articulated but constituted. Within the theoretical framework of Material Engagement Theory (MET) developed by Malafouris (2013) cognition is not understood only as a process confined within the boundaries of the brain, but rather as something enacted through embodied action and materially situated practices. Malafouris' central claim is that material engagement is constitutive of thought itself, not merely supportive or expressive of mental content.

Based on this theoretical foundation, handwriting can be reinterpreted as a form of material engagement in which thought and material co-emerge. While Malafouris himself does not focus extensively on handwriting as a contemporary educational practice, his analysis of the emergence of writing in ancient Mesopotamia provides an interesting precedent. Malafouris (2013, ch. 4) considers how the use of clay tablets and styluses in early administrative contexts—not merely as tools for storing external information—reshaped the very structure of cognitive operations. The act of impressing signs into clay was not only a way of recording data, but also a novel form of reasoning that made possible new kinds of abstraction, classification, and accountability.

What is particularly significant in Malafouris' account is that the material medium does not merely support cognition but actively reorganizes it. The constraints and affordances of clay—its resistance, plasticity, and spatial structure—shaped the kinds of operations that could be performed, enabling new forms of categorization, abstraction, and accountability. In this sense, early writing practices did not merely externalize pre-existing thoughts but actively participated in their formation, which is the most relevant point in this context.

A similar dynamic may be observed in contemporary handwriting. The resistance of the pen, the continuous motor feedback, and the temporal unfolding of inscription impose a rhythm that slows down cognition and fosters integration between perception, action, and reflection. By contrast, the increasing dematerialization of writing through digital interfaces may weaken this coupling between thought and material engagement, potentially altering not only how we write, but how we think. From this perspective, the decline of handwriting in educational contexts may not simply reflect a change in tools, but a deeper transformation in the material conditions under which cognition develops.

Applied to the development of critical thinking, this view has significant implications. As noted above, handwriting, by virtue of its temporal and tactile qualities, enforces a rhythm of engagement that contrasts with the speed and fluidity of digital typing. The physical act of forming letters by hand requires motor coordination, spatial planning, and temporal sequencing—all of which ground abstract reasoning in sensorimotor experience (James, 2017).

As evidence of such relevance of handwriting on cognitive capacities, researchers found that students who take notes using a keyboard do not retain lesson content as effectively as those who write by hand; and that learning outcomes are even better when notes are taken in cursive rather than print handwriting (Cytowic, 2024, ch. 17). Moreover, writing in cursive has been shown to enhance the attentional capacity of note-takers (Mueller & Oppenheimer, 2014; Van der Meer & Van der Weel, 2017). The brain regions activated during handwriting differ from those involved in typing (Ardila, 2018, ch. 4). Handwriting promotes the formation of connections between memory-related and learning-related brain areas, effectively introducing a cognitive filter on the information being recorded—an effect not typically observed with digital tools.

Furthermore, neural activations in seven-year-old children who engaged in handwriting practice, compared to control groups who merely observed the process, indicate that learning is driven by self-directed effort rather than passive feedback. Accordingly, handwriting, as an action that is actively performed, tends to produce lasting effects that extend to other cognitive domains (Kersey & James, 2013; James & Engelhardt, 2012). Finally, unlike educational apps, the acquisition of cursive handwriting yields measurable cross-domain benefits: it demands high levels of focus and eye–hand coordination, which in turn enhance neural connectivity (Cytowic, 2024, ch. 17; Planton et al., 2013).

Based on the evidence above, the increasing substitution of handwriting with digital devices in educational settings risks detaching cognitive practices from the material engagements that support them. Accordingly, while digital tools offer certain efficiencies, they may also reduce opportunities for the kind of reflective, integrative thinking that argumentative writing, writing practices more broadly, and handwriting promote, a form of thinking essential to critical reasoning.[2]

3. GenAI challenges the development of critical thinking through argumentative writing

As noted in the Introduction, the widespread adoption of digital tools, and more recently, the rapid proliferation of generative artificial intelligence (GenAI) systems, poses a growing challenge to the cognitive ideal of critical thinking and the pedagogical practices that support it. As we argued in Section 2, the practice of argumentative writing scaffolds critical

[2] Children and adolescents with special educational needs, or dyslexia may face significant difficulties with handwriting, or cursive handwriting. For this reason, we acknowledge that while our argument stresses the importance of (hand)writing for the development of critical thinking skills, school curricula should still consider the diverse needs of all students, aiming to promote tools that foster critical thinking in ways that are appropriate for each learner, and without imposing universal methods.

thinking skills. However, tools such as large language models (LLMs) can generate fluent and seemingly coherent texts on demand, potentially reshaping habits of learning, reasoning, and writing across both educational and professional contexts.

At this point, we need to distinguish between cognitive offloading and cognitive deskilling. Cognitive offloading (Risko & Gilbert, 2016) is often an adaptive strategy that allows individuals to optimize cognitive resources by relying on external support. Significantly, offloading can become problematic when it leads to deskilling, that is, a durable reduction in internally available cognitive capacities. This transition is more likely to occur when external tools systematically replace, rather than support, the effortful processes involved in learning—particularly during developmental stages in which such processes are still being consolidated.

From this perspective, the use of large language models (LLMs) risks promoting cognitive offloading and deskilling, weakening epistemic engagement, and eroding the evaluative and dialogical processes that are central to the development of critical thinking. Thus, our concern is not with offloading per se, but with patterns of reliance that may gradually undermine the acquisition of critical thinking skills.

This issue is extremely relevant. While much of the literature focuses on the advantages in terms of accessibility and efficiency that LLMs undoubtedly offer when teachers introduce them in the classroom to support student learning (see Deng et al., 2025 for a meta-analysis), research also shows that students increasingly rely on the assistance of LLMs for assignments *without* consent of, or disclosure to the teacher (Sidoti et al., 2025).

Several factors help explain the increasing trust among students in the assisted work provided by LLMs. First, LLM-generated feedback can increase students' revision performance (Meyer et al., 2024), and students consider LLM-generated feedback to be helpful and qualitatively good (Gubelmann et al., 2024). Moreover, the quality of argumentative writing assignments performed by LLMs has improved to the point that teachers (Fleckenstein et al., 2024; Herbold et al., 2023), plagiarism detection tools (Khalil & Er, 2023), and even examination systems (Scarfe et al., 2024) have lost the capacity to identify AI-generated texts as opposed to student-generated ones.

Taken together, these data reinforce the appeal of delegating the production of written arguments to machines for students. This is not problematic per se, as students may exploit LLMs just as proofing or copyediting tools (Bekker, 2024), or for brainstorming ideas, summarizing texts, and locating relevant research articles (Ravšelj et al., 2025), or to anticipate potential objections (Kudina et al., 2025). However, it can become an issue when they delegate most of the planning and writing to LLMs. In this case, the essential cognitive labor of writing may be displaced, and with it, the developmental benefits associated with critical thinking.

Studies confirm such a risk. Zhang & Xu (2025), for instance, submitted a survey to university students to explore the direct and indirect effects of generative AI usage frequency on AI dependence. They found a paradoxical result: while increased AI usage correlated with students' confidence and learning efficiency, it was also associated with a reduction of autonomous learning. Integrating these data, Gerlich (2025) conducted surveys and in-depth interviews with participants from a range of age groups and educational backgrounds. He found a significant negative correlation between frequent AI tool usage and critical thinking abilities, mediated by increased cognitive offloading. In particular, younger participants exhibited higher dependence on AI tools and lower critical thinking scores compared to older participants.

These results suggest that the use of AI can reduce both students' independent learning and critical thinking. In the case of argumentative writing assignments, this may imply that students more prone to generating argumentative text with LLMs will more likely overuse the opportunity, thereby missing an important chance to train their critical thinking skills, and grow them in mature, autonomous capacities.

In addition, students' use of LLMs in argumentative writing assignments might negatively impact critical thinking skills through a second, more subtle and specific dynamic. The pedagogical value of argumentative writing relies on the premise that composing a reasoned argument is cognitively demanding and obliges the writer to engage in and organize the results of a variety of activities: collecting relevant information, and structuring evidence coherently and logically—together with taking epistemic responsibility for claims, and engaging critically with competing viewpoints (Karbach, 1987; Toulmin, 2003).

However, evidence suggests that, when collecting information is achieved through LLMs, justification capacities also decrease. Stadler et al. (2024) contrasted students' use of LLMs as opposed to traditional search engines to search for information on the web and derive justified valid recommendations. They found that students using LLMs experienced lower cognitive load but significantly provided lower quality justifications than those in the search engine group. The finding replicates our general discussion to the specific skills necessary for argumentative writing: while using LLMs can simplify data gathering, it also detours students from engaging in deep learning, which in turn results in a more limited capacity to justify recommendations provided.

4. Pedagogical ways out

The results just discussed do not undermine the fact that, under appropriate pedagogical conditions, generative AI can support rather than hinder the development of higher-order cognitive skills (Chiriatti et al. 2024). For instance, AI-generated texts may serve as objects of critical analysis, prompting students to identify weaknesses, detect biases, compare alternative formulations, and refine their own arguments. Similarly, AI-assisted feedback can facilitate revision processes and enhance metacognitive awareness, as suggested by recent empirical studies (e.g., Meyer et al., 2024). These uses do not replace the cognitive effort involved in thinking, but reconfigure it, shifting the focus from production to evaluation and critical engagement. Therefore, a balanced pedagogical approach should also aim to structure AI use in ways that preserve and extend students' reflective capacities.

Recent literature offers a range of ideas aimed at mitigating this risk and reconfiguring pedagogy to preserve and strengthen students' reflective and evaluative capacities in AI-mediated learning environments. In what follows, we review a selection of such proposals, which are still largely based on limited empirical data. Most authors take for granted the widespread integration of new technologies into education and propose strategies for incorporating generative AI into instructional practices in ways that safeguard the emergence and development of critical thinking. This capacity is treated as a foundational element of education, one that must not be sacrificed on the altar of efficiency and speed in content production enabled by digital tools and AI systems.

A central theme is the necessity of shifting from content transmission to active, inquiry-driven pedagogy. Kenedy (2024) critiques the dominant "banking model" of education (drawing on Freire, 1970) in which students are treated as passive recipients of content—including AI-generated content—rather than active constructors of meaning. To counter this, he proposes a Cyclical Critical Thinking Model rooted in active learning, independent reasoning, and critical engagement with AI outputs, emphasizing the need for transferability or "portability" of critical thinking skills into civic and professional life.

Similarly, Stuchlikova and Weis (2024) emphasize that AI tools, while rich in information, often produce superficial explanations lacking conceptual depth. They advocate for explicit instruction in logic, scientific reasoning, and epistemic humility to counteract overreliance on AI-generated answers. Educators must guide students to critically assess the limitations and assumptions of AI tools, and to develop their own interpretive insights. This aligns with their call for bridging philosophical traditions of critical thinking with modern technological fluency.

A more structured curricular approach is suggested by Gonsalves (2024), who revisits Bloom's taxonomy (1956) in light of GenAI's cognitive capabilities. Since GenAI can simulate higher-order outputs like evaluation and creation, Gonsalves argues that educational design must scaffold students' critical engagement with AI itself, such as questioning the validity of responses, refining prompts, and comparing AI outputs with human reasoning. These metacognitive practices transform AI from a surrogate for thinking into a catalyst for deeper learning.

The work of Lubbe and colleagues (2025) converges on this point by proposing the reintegration of Bloom's taxonomy with assessment design, emphasizing iterative feedback, self-directed learning, and peer discussion around AI-generated material. They advocate for reframing assessment pedagogy to ensure that students not only use GenAI tools, but also reflect critically on their output within collaborative, socially constructed learning environments, a perspective grounded in Vygotskian social constructivism.

From a complementary angle, Spector and Ma (2019) stress the importance of reinforcing human intelligence alongside artificial intelligence, especially from early educational stages. They argue for long-term investment in critical thinking as a developmental process, supported—but not replaced—by AI. Their work implies that AI tools should be treated not as cognitive shortcuts, but as opportunities to provoke deeper inquiry and ethical reflection.

Finally, Chan and Hu (2023) highlight students' mixed perceptions of GenAI, valuing its productivity but expressing concern about its impact on personal development. They recommend promoting AI literacy and reflective dialogue to help students understand not only how to use GenAI tools, but also how to critically evaluate their outputs. This student-centered perspective supports a pedagogical shift from automation to critical mediation.

5. Discussion and conclusion

Taken together, the considered contributions converge in claiming that the challenge posed by GenAI to critical thinking is not inevitable. With deliberate instructional design, thoughtful integration, and ethical reflection, higher education can harness AI's capacities without undermining the cognitive virtues at the heart of critical inquiry.

It is important to emphasize that such optimism has yet to be confirmed by large-scale empirical studies, while a general decline in critical thinking appears to be emerging within contemporary societies. For this reason, some countervailing considerations are warranted. First, both the social pressure to increase productivity and the psychological tendency toward cognitive "laziness"—that is, the pursuit of maximum outcomes with minimal effort, a trait shaped by evolutionary processes—suggest that the widespread availability of algorithmic tools, such as generative AI chatbots, will on average outweigh efforts to preserve critical thinking in the context of new technologies.

This tendency can be possibly interpreted within dual-process theories of cognition, according to which individuals are naturally inclined to rely on fast, low-effort cognitive

strategies (often referred to as "System 1"; Kahneman, 2011) whenever possible, reserving slower and more demanding forms of reasoning ("System 2") for situations that explicitly require them. In this framework, the availability of powerful AI tools may systematically lower the threshold at which effortful reasoning is engaged, thereby reinforcing a preference for economical cognitive strategies over reflective deliberation.

Second, and perhaps even more importantly, it is insufficient to place the entire burden of defending critical thinking on the educational system alone. Current generative AI tools are opaque, and their outputs cannot be reliably verified—even by expert users—without a significant investment of time and effort, which would largely defeat the purpose of using such systems. There is therefore a broader societal responsibility that must be assumed by major technology companies, regulatory bodies, and states to ensure that these widely used chatbots, often treated as modern-day oracles, become more transparent, trustworthy, and neutral. Encouraging a pluralism of "transparency" tools, including linguistic and cultural diversity, in many fields of AI application would contribute to preserving the conditions under which critical thinking, as we understand it, can remain viable in an era shaped by generative AI.

In this vein, it may be recommended—before we reach the paradox whereby a decline in critical reasoning increases our dependence on machines—that we not only develop strategies for integrating new tools into educational practice, but also resolutely preserve existing methods for fostering fluid intelligence and divergent thinking. These include, in particular, handwriting instruction for children and argumentative writing across all levels of formal education.

It may also be necessary to consider placing limits on the use of generative AI in educational and training contexts or even banning it during certain critical stages of learning (Bekker, 2024). Obviously, limitations should be carefully calibrated, and different educational stages may require different approaches. Early phases of learning, in which foundational cognitive skills are still developing, may justify stricter limitations on AI-assisted writing, whereas more advanced stages may benefit from structured and reflective uses of such tools.

In addition, it is important to ensure that restrictions on the use of generative AI tools do not inadvertently exacerbate existing inequalities. Students from under-resourced contexts, non-native speakers, or learners with specific educational needs may derive significant benefits from AI-assisted support. For this reason, any normative framework on education should balance the protection of cognitive development with considerations of fairness and accessibility.

To conclude, liberal-democratic societies are grounded in the cultivation of critical thinking, and it would be a deeply ironic and undesirable nemesis if the very technological advances—driven by creative intelligence unbound by rigid frameworks—ultimately undermined the conditions that made such progress possible. What is ultimately at stake is the preservation of epistemic responsibility, understood as the agent's obligation to take ownership of the justificatory grounds of their beliefs by actively engaging in their evaluation, without passively delegating them to external systems. If this responsibility is progressively weakened, the risk is both a decline in individual critical thinking and a broader transformation in the epistemic culture of democratic societies. Conversely, when this responsibility is consciously assumed and actively maintained, AI can become a powerful tool for fostering individual intellectual growth and promoting the positive development of human societies.

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