The Neurocognitive Implications of Using ChatGPT in the Writing Process by Young Children

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Abstract

The rapid adoption of ChatGPT in education has sparked both enthusiasm and concern, particularly regarding its impact on the cognitive aspects of writing. Despite its potential to personalize learning and provide scalable writing support, little is known about ChatGPT's effects on thinking skills that depend on writing and writing skills that depend on thinking. This literature review examines the neurocognitive implications of integrating ChatGPT into the writing processes of children aged 5–11, synthesizing evidence from 216 sources through a transdisciplinary lens informed by fields including language, technology, education, cognitive neuroscience, and developmental psychology. Writing is presented as a meta-skill essential for cognitive development across subjects. Evidence shows that AI writing assistants can provide personalized scaffolding, expand feedback, and strengthen metacognitive engagement. However, risks include cognitive offloading, diminished student voice, and bypassing critical stages in cognitive development, such as planning and revision. The review reveals that ChatGPT's impact appears to be contextually dependent rather than inherently beneficial or harmful, with effects varying across different stages of the writing process. A stage-by-stage analysis demonstrates that the same AI features can either support or hinder cognitive development depending on timing, instructional context, and developmental readiness. Findings suggest balancing benefits and risks depends on three elements—instructional design, adult guidance, and AI literacy—working together to preserve the developmental cognitive goals of writing education. This paper proposes preliminary, evidence-informed criteria for developmentally appropriate integration and outlines stakeholder roles for educators, parents, policymakers, researchers, students, and technology developers. As the long-term cognitive effects of sustained AI-supported writing cannot yet be measured due to its newness, research needs include readiness for prompting, children's

ability to detect AI bias, and diminished rehearsal of important cognitive functions upon which higher order cognition is developed. The review calls for skeptical optimism to leverage ChatGPT's potential while applying safeguards grounded in writing pedagogy and child development. Immediate, coordinated action paired with ongoing research is essential to ensure AI integration strengthens learning, safeguards cognitive growth, and prepares children for a future where AI is integral to daily life.

Keywords: writing process, cognitive development, children, ChatGPT, executive functions, AI literacy, AI writing assistants, young writers, AI in education, writing instruction.

The Neurocognitive Implications of Using ChatGPT in the Writing Process by Young Children

Writing is one of the most cognitively demanding tasks humans can perform (Kellogg, 2008; Tokuhama-Espinosa et al., 2024). It requires the integration of hundreds of neural pathways, including those related to language, memory, executive functions, and emotions among others, and is considered the most complex cognitive activity the human brain can undertake at any given moment (Tokuhama-Espinosa et al., 2024). Unlike spoken language, which develops naturally, writing must be explicitly taught and scaffolded (Dehaene, 2009), meaning learners rely on structured tasks, modelling, and practice to strengthen the cognitive pathways necessary for flexibility and intellectual growth (Ruffini et al., 2024). Writing not only facilitates expression and communication but also significantly contributes to children's cognitive development, enhancing skills essential for academic success, intellectual growth, and societal engagement (McCutchen, 2006; Ruffini et al., 2024). Writing rehearses key cognitive functions that improve thinking skills (Applebee, 1984; Graham et al., 2020; Menary, 2007, Oatley & Djikic, 2008), and is culture’s most prized artifact (Spivey, 2023). Due to the complex nature of writing, interested parties including parents, educators and policymakers among others, have begun to examine writing tools now available through Artificial Intelligence (AI), such as the AI-writing assistant ChatGPT (Bai et al., 2023; León-Domínguez, 2024), and their impact on the cognitive processes involved in writing.

ChatGPT, developed by OpenAI in 2019 and released to the public in November 2022, is an advanced natural language processing (NLP) model that employs deep learning algorithms to generate conversational text responses that are indistinguishable from human writing (Lebrenz et al., 2023; Lund & Wang, 2023; Rudolph et al., 2023). ChatGPT

generates text by synthesizing pre-existing human knowledge, allowing it to assist adolescents and adults with tasks such as brainstorming, summarizing, and essay composition (Su & Yang, 2023). Released on May 13, 2024, GPT-4o was the most recent publicly available version of ChatGPT at the time when most of the studies cited in this review were conducted. Since then, OpenAI has introduced GPT-5 (2025), but the existing research base primarily reflects earlier GPT-3, GPT-3.5, and GPT-4 models (OpenAI, 2024, 2025). ChatGPT has quickly become the fastest adopted software in history. Its public and free availability has enabled its widespread use across various fields, including technical skills, personal communication, education, scientific advancement, and creative industries. This rapid adoption is driven by its versatility and accessibility (Léon-Domínguez, 2024), with researchers highlighting its potential to enhance personalized learning and productivity (Luo et al., 2024; Su & Yang, 2023). However, concerns have been raised about its impact on cognitive engagement and originality, particularly when used in the context of writing education (Bai et al., 2023; Campbell, 2023; Luo et al., 2024).

The purpose of this paper is to leverage a transdisciplinary approach including perspectives from neuroscience, psychology, mental and physical health, and wellbeing, as well as pedagogical practices from the MBHE (Mind, Brain, Health, and Education) fields, to examine how reliance on AI writing assistants such as ChatGPT affects cognitive development of young children during the writing process. By focusing on the interplay between the science of writing and the role of AI, this study seeks to address gaps in understanding the potential implications of ChatGPT on foundational writing skills and the underlying cognitive processes, based on a literature review.

Background

The Science of Writing: A Cognitive Perspective

Writing is not merely a skill that needs explicit instruction, but rather a cognitive process that deeply intertwines with thinking, forming a mutually reinforcing loop (Tokuhama-Espinosa et al., 2024). Through iterative tasks such as planning, organizing, and revising, writing helps learners translate often abstract thoughts into structured language, strengthening neural pathways and enhancing cognitive flexibility. Writing serves a dual role both as a tool for expressing ideas and as a structured mechanism for organizing and refining thought. More than just reflecting existing knowledge, writing engages learners in a continuous cycle of internal reasoning and external articulation, prompting deeper cognitive processing (Menary, 2007). This iterative process, which moves between shaping ideas internally and restructuring them in written form, plays a crucial role in cognitive development by fostering self-reflection, critical thinking, and problem-solving (Tokuhama-Espinosa et al., 2024).

The process of learning to write, even more than reading, demands deliberate teaching and structured scaffolding to guide the development of essential neural pathways and cognitive skills (Tokuhama-Espinosa et al., 2024). Writing improves reading (Graham & Herbet, 2011), and reading improves writing (Graham et al., 2018). While the science of reading has drawn attention to the neural mechanisms underpinning the reading process (e.g., Snowling et al., 2022), the writing aspect of literacy instruction is still in its infancy. Despite advances, scientists nor teachers have perfected how to teach children to read, and even less progress has been made in teaching them to write effectively (Malpique et al., 2024). This gap is reflected in international data showing that on average, 26% of adults in Organisation for Economic Co-operation and Development (OECD) countries score at or

below Level 1 in literacy, indicating difficulties with basic reading comprehension and processing skills essential for effective learning and communication (OECD, 2024). Although writing proficiency is not directly assessed in the OECD survey, its close relationship with reading skills (Graham et al., 2018) suggests that writing abilities may face a similar state or be possibly worse. These literacy challenges have profound societal implications, including reduced access to employment opportunities, limited civic engagement (Compton-Lilly et al., 2020), and even changes the physical brain structure that may affect long-term cognitive adaptability (Roy, 2025).

It stands to reason that knowledge about how the brain learns to write should be taken into consideration when evaluating teaching methodologies and their efficiency. These limitations in our understanding and teaching practices are further complicated by the introduction of AI writing assistants like ChatGPT. Since ChatGPT is a recent innovation, its usage by both teachers and students remains exploratory, as clear guidelines for its appropriate and effective integration into education are still lacking.

ChatGPT's Role in Writing Education

Like any tool, ChatGPT has both advantages and disadvantages. The emergence of ChatGPT introduces new possibilities for addressing difficulties in writing education. ChatGPT can support personalized learning by providing real-time guidance, text generation, and feedback, making it a potential tool for productivity, skill-building, and instructional support (Luo et al., 2024; Su & Yang, 2023; Tseng & Warschauer, 2023). Some studies suggest that when integrated effectively, ChatGPT may enhance critical thinking and writing proficiency (Luo et al., 2024). As an AI-driven system, ChatGPT can align with adaptive learning models, like Intelligent Tutoring Systems (ITS), which adjust learning paths based on individual progress (Su & Yang, 2022). These AI-driven systems offer

personalized guidance, adapting instruction to students' evolving educational needs. However, it remains unclear whether these tools cultivate deep learning or encourage surface-level engagement (Su & Yang, 2022). ChatGPT's impact on learning is not determined by the nature of AI-generated content but by how students engage with it in educational contexts. That is, whether they use it as a tool for deep learning and independent thought or rely on it passively. If used to bypass cognitive processes underlying writing production such as brainstorming, revision, and reflection, such cognitive off-loading weakens essential skills in concept development and iterative refinement (Beck & Levine, 2023; Campbell, 2023; Su & Yang, 2022). Despite these concerns, ChatGPT's increasing use in education and other fields suggests that its capabilities could significantly reshape learning environments. Some researchers argue it has potential to significantly enhance productivity and could even alter the trajectory of humanity (León-Domínguez, 2024; Peters et al., 2024).

What Is Still Unknown: Gaps in The Literature From a Transdisciplinary Perspective

Current studies on ChatGPT in education primarily use surveys or experimental methods, and research remains largely theoretical (Bacon & Torremucha, 2025). There are no empirical neuroscience studies that have directly examined the brain's response to ChatGPT-assisted writing in young children. While some research in science education and in higher education examines AI-writing assistants usage from both student and educator perspectives, there is a notable lack of studies on its use in early childhood education (ECE), kindergartens, and primary schools (Luo et al., 2024). The few studies available show there are benefits to using ChatGPT under teacher supervision (e.g., Kızıltaş, 2025), and that human-child interface differs from ChatGPT-child interface in the quality of emotions

contributing to language learning processes including working memory, planning, volition, conscious recall, and joint attention (Grossberg, 2023), cognitive processes that underpin the ability to write.

The Problem

Despite often requiring adult assistance to access the tool, young children remain potential users, particularly as ChatGPT's features like voice commands and speech-to-text make it increasingly accessible (Luo et al., 2024). This research focuses on children aged 5 to 11, defined as “developing writers,” whose cognitive skills during this stage form the foundation for future writing proficiency (Ruffini et al., 2024). Neuroconstructivist theory (Tokuhama-Espinosa & Borja, 2023) emphasizes the sequential nature of learning, where foundational skills acquired in early childhood, such as storytelling, vocabulary acquisition, and sentence formation, form the basis for advanced writing capabilities. Skipping these foundational skills risks gaps in neural connectivity, potentially hindering mastery of advanced tasks like coherent essay writing or critical text analysis (Tokuhama-Espinosa & Borja, 2023). It is still unknown if ChatGPT pre-empts skills acquisition by “skipping” steps in the neuroconstructivist development of writing skills. The lack of research on the cognitive impacts of AI writing assistants for this age group underscores the need for deeper investigations. This paper takes the first step by identifying cognitive functions that may be affected by usage of AI writing assistants while also sharing current understanding to guide immediate considerations. Ensuring these tools respect the progressive layering of knowledge and align with cognitive readiness is critical to not compromise the development of future generations of thinkers. Future experimental neuroscience studies are essential to

quantify these impacts and provide evidence-based support for AI implementation guidelines in early education.

Research Question

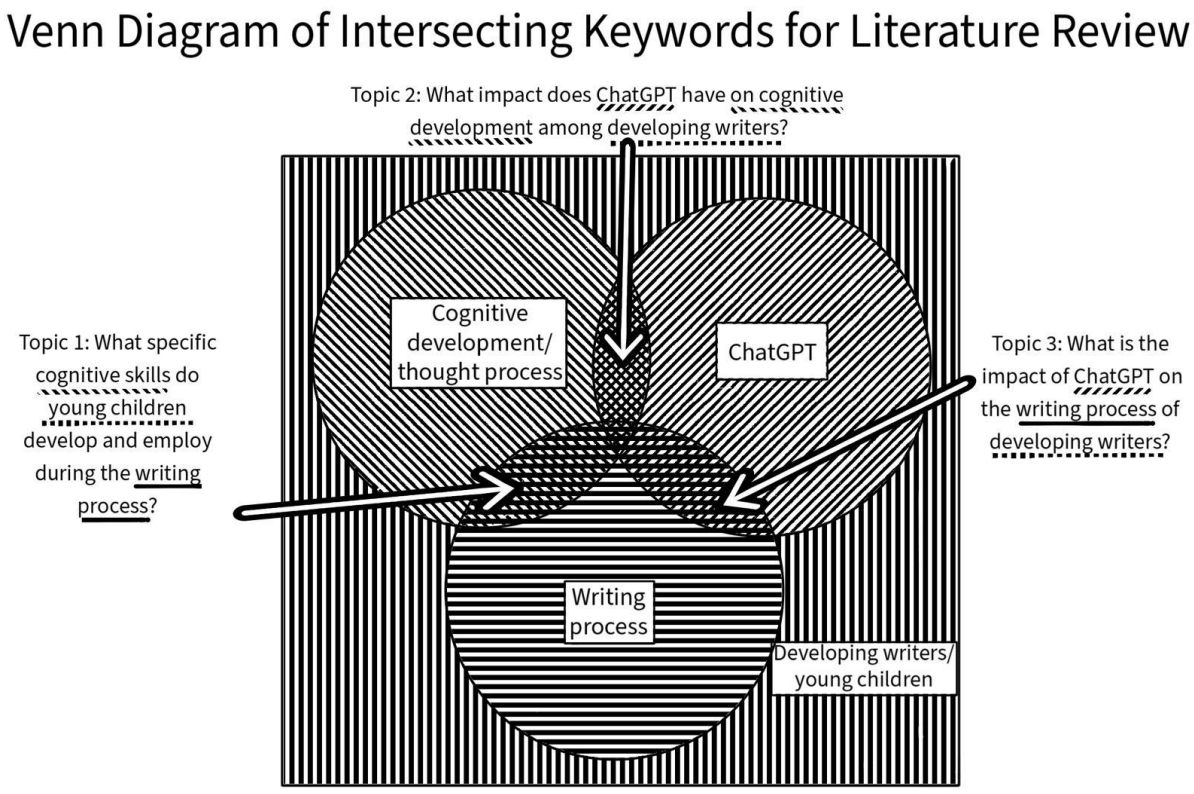
To respond to these gaps in the literature, the research question that drives this paper: How and to what extent does ChatGPT influence the cognitive processes underpinning writing in young learners?

Literature Review

Topics of the Literature Review

To address the research question, “How and to what extent does ChatGPT influence the cognitive processes underpinning writing in young learners?” the literature review is divided into three main areas: cognitive development and thought processes; ChatGPT; and the writing process (Figure 1). These three areas will be examined as they relate to emergent writers.

Figure 1 Venn Diagram of Intersecting Keywords for Literature Review



NOTE: The main research question and sub-topics of the current literature were determined by finding the intersection of research on cognitive development, ChatGPT, and the writing process.

As shown in the Figure 1, the literature review was split into three secondary topics that were formed as questions listed below and were analyzed through the transdisciplinary lens which included neuroscience, psychology, mental and physical health and wellbeing, as well as pedagogical practices, collectively known as the MBHE (Mind, Brain, Health, and Education) fields:

1. What specific *cognitive skills* do *young children* develop and employ during the *writing process*?
2. What impact does *ChatGPT* have *on cognitive development* among *developing writers*?
3. What is the impact of *ChatGPT* on the *writing process* of *developing writers*?

These three questions will be answered and then a summary review of the main research question will be addressed.

What Specific Cognitive Skills Do Young Children Develop and Employ During the Writing Process?

To understand the foundational role of writing in young learners' cognitive development, this section organizes the discussion into three interrelated areas. First, it outlines the cognitive functions that underpin writing and how these are activated and developed through practice. Next, it highlights the importance of instructional design, focusing on how thoughtful teaching strategies can support and enhance these processes. Lastly, it explores writing's broader role as a tool to bridge learning across various fields, facilitating connections between writing and other academic skills.

Cognitive Processes Used and Developed During the Writing Process

Writing is a complex cognitive skill that requires coordination between language processing, memory, executive functions, and other cognitive processes (Torrance et al.,

2007), as well as the involvement of motor functioning to physically write (Costa et al., 2022). To explain how these elements interact, researchers have proposed multiple theoretical models. One of the most influential is Hayes and Flower's Cognitive Model of Writing (Flower & Hayes, 1981), which identified writing as an iterative process composed of three essential stages:

- Planning: Brainstorming and organizing ideas before writing.
- Translating: Converting ideas into written text.
- Reviewing: Revising and modifying the text to refine meaning and coherence.

As writing research progressed, newer models expanded upon this framework (Ruffini et al., 2024). One of the most comprehensive is the Direct and Indirect Effects Model of Writing (DIEW model), which not only integrates but also extends insights from the Flowers and Hays model through two perspectives:

1. The Simple View of Writing: Suggests that writing proficiency depends on two foundational skills—ideation (expressing ideas in written form) and transcription (basic writing mechanics) (Berninger et al., 2002; Juel et al., 1986).
2. The Not-So-Simple View of Writing: Proposes that in addition to basic linguistic skills, working memory, executive function, and metacognitive awareness play a crucial role in writing (Berninger & Amtmann, 2003; Berninger & Winn, 2006; McCutchen, 2006; Peng et al., 2022; Ruffini et al., 2024).

The DIEW model expands on previous perspectives by showing how foundational skills like transcription support higher-order cognitive abilities such as reasoning and self-regulation, emphasizing the necessity of balancing both views for writing proficiency. It further

acknowledges oral language, background knowledge, and motivation as essential to writing development (Kim & Park, 2019).

Research on the cognitive processes involved in writing has primarily focused on adults. However, Ruffini and colleagues (2024) have pioneered a systematic review exploring how writing interacts with executive functions in children. Executive functions, as defined by Hooper and co-authors (2006), are “the higher-order control processes that regulate cognition during tasks such as planning and self-monitoring” (p. 222). Ruffini’s lab showed that writing both relies on and enhances cognitive functions. The literature identifies several cognitive functions foundational to the writing process, including major areas of general cognitive abilities dependent of well-functioning memory systems and well-functioning attention systems (Tokuhama-Espinosa et al., 2024), and motor skills needed for writing (Chandler et al., 2021). Additionally, a great number of studies can be found related to the following five areas which serve as umbrella concepts under which several neural networks are documented to underpin writing:

- Memory systems: storing and retrieving knowledge to support writing.
- Attention systems: sustaining focus on and concentration.
    - Executive Functions (EF): inhibition, working memory, cognitive flexibility, problem-solving, and planning.
        - Self-Regulation: the behavioral expression of EF that integrates attention, inhibition, and working memory, enabling children to sustain focus, resist distraction, and flexibly coordinate composing with transcription demands.
- Critical Thinking

- Theory of Mind: understanding others' perspectives, which influences audience awareness in writing (a subset of social cognition).
- Meta-Linguistic Awareness: the ability to reflect on language structure and use (a subset of linguistic cognition).

Table 1 provides an overview of how some important cognitive functions and their underlying neural substrates operate within the writing process and how they develop over time through continuous writing practice.

Table 1 Cognitive Functions Employed and Developed During Writing Process

Cognitive Function	How is the given cognitive function employed during writing?	How is the given cognitive function developed thanks to the process of writing?	Sample References
***General Cognitive**: Long-Term Memory*	Long-term memory provides children with a wealth of vocabulary, grammar and past experiences to draw upon while writing.	As children write more, they enhance their long-term memory capabilities by regularly engaging in the process of recalling, using, and integrating previously learned information into new contexts.	Guimaraes (2023); McCutchen (2006); Ruffini et al. (2024); Skar et al. (2024) Guimaraes (2023); McCutchen (2006); Ruffini et al. (2024)
***General Cognitive**: Attention*	Attention allows children to focus on writing tasks by avoiding distractions, which is crucial for maintaining the quality of their work.	Frequent writing exercises enhance children's attentional control, improving their ability to concentrate on complex as well as detailed-oriented tasks.	Campbell & Cunningham (2025); Guimaraes (2023); Kuo et al. (2024); Quinn et al. (2022); Quinn & Rohloff (2025); Ruffini et al. (2024).
Executive Functions	During writing, children use inhibition to suppress their initial responses, allowing for	Through writing practice, children enhance their inhibition,	Altemeier et al. (2006); Cordeiro et al. (2020);

Cognitive Function	How is the given cognitive function employed during writing?	How is the given cognitive function developed thanks to the process of writing?	Sample References
***(basic)**: Inhibition*	thoughtful and relevant writing by selectively choosing words and ideas that best express their thoughts, improving text coherence.	which helps them maintain focus and select appropriate content more effectively.	Drijbooms et al. (2015); Drijbooms et al. (2016); Guimaraes (2023); Rocha et al. (2022); Ruffini et al. (2024)
***Executive Functions (basic):** Working Memory*	Working memory assists children in holding and manipulating necessary information while writing, enabling the integration of new text with information retrieved from long-term memory, which supports both text generation and transcription processes.	Writing activities strengthen children's working memory by gradually automating routine processes, which then frees up cognitive capacity for more complex tasks such as planning and execution, thereby enhancing their ability to manage detailed and extensive writing projects.	Baddeley (2010); Cardoso et al. (2024); Cave (2010); Drijbooms et al. (2016); Guimaraes (2023); Shvartsman & Shaul (2024); Kim (2024); Latham (2002); McCutchen (2006); Ruffini et al. (2024); Truxius et al. (2025)
***Executive Functions (basic)**: Cognitive Flexibility*	Cognitive flexibility enables children to switch between different narrative elements or adjust their writing style as needed. This also permits for analogical thinking.	Regular writing practice and engaging in diverse writing tasks promotes the growth of cognitive flexibility in children, allowing them to switch between ideas and perspectives more easily.	Drijbooms et al. (2016); Ruffini et al. (2024); Tal & Shaul (2024)
***Executive Functions (basic):** Self-regulation*	Children use self-regulation to stay focused, manage competing demands, and flexibly switch between planning, transcription, and revision. Stronger regulation supports persistence and effective goal monitoring, including sustaining attention,	Across the early years, growth in writing predicts later gains in self-regulation, as children practice sustaining attention, controlling impulses, and adapting strategies. These	Cartwright et al. (2023); Chandler et al. (2021); Klein et al. (2022); Puranik & Li (2022); Skar et al. (2023)

Cognitive Function	How is the given cognitive function employed during writing?	How is the given cognitive function developed thanks to the process of writing?	Sample References
	avoiding distractions, controlling frustration, and monitoring progress toward writing goals. The contribution of self-regulation is most evident in challenging tasks, where it supports performance and can compensate for weaknesses in other foundational skills such as fine-motor control and other basic processes.	benefits are strongest when tasks are demanding enough to stretch ability but still within reach with guidance. In addition, children who develop stronger beliefs in their ability to regulate writing tend to produce higher-quality texts.	
Executive Functions (higher): *Problem-Solving*	Children employ problem-solving to decide the best ways to connect and present ideas, as well as improve them based on feedback, enhancing the readability of their writing.	Through the process of writing, revising, and receiving feedback, children enhance their problem-solving abilities, improving their text organization and fostering more effective decision-making.	Cave (2010); Drijbooms et al. (2016); Guimaraes (2023); Hawkins et al. (2024a); Hawkins et al. (2024b); McCutchen (2006); Olson (2002); Ruffini et al. (2024)
Executive Functions (higher): *Planning*	Planning helps children organize their ideas and involves deciding on the sequence of events or the layout of information, which aids in producing more organized texts.	Initially, children may not engage in extensive planning, but as children engage in writing, they gradually improve their planning skills, which helps them structure their thoughts more effectively.	Cave (2010); Gabas et al. (2022); Guimaraes (2023); Harmey (2021); McCutchen (2006); Nicol & Pletcher (2025); Rohloff et al. (2024); Ruffini et al. (2024)

Cognitive Function	How is the given cognitive function employed during writing?	How is the given cognitive function developed thanks to the process of writing?	Sample References
Learned process: *Critical thinking*	Critical thinking is essential for the evaluative aspects of writing, as it involves the analysis, synthesis, and evaluation of ideas, playing a fundamental role in the revision process and the development of coherent arguments.	Critical thinking skills progress with the experience and age of young writers, initially triggered by external feedback and suggestions, and eventually evolving into the ability to self-revise and critique their own work.	Aktoprak & Hursen, 2022; O'Reilly et al., 2022; Nasution & Afrianti (2022); Papadopoulos & Bisiri (2020); Putri & Widyasari (2020); Salinger (2012)
Disposition: *Theory of Mind*	The development of theory of mind (ToM) in writing enables writers to consider their readers' perspectives and state of mind, shifting from a simple knowledge-telling strategy to more sophisticated audience-aware writing that incorporates higher-order thinking skills.	Children's ToM develops through the practice of writing from different characters' perspectives, enhancing their understanding of diverse mental states.	Brazzelli et al., 2022; Cave (2010); Drijbooms et al. (2016); Guimaraes (2023); Meadows (2017); Ruffini et al. (2024); Shahaeian et al., 2023
Ability: *Meta-linguistic awareness*	Meta-linguistic awareness aids children in understanding the nuances of language use and structure, which they apply to improve their writing.	Writing regularly helps children recognize and use linguistic structures more effectively, thus improving their meta-linguistic awareness.	Latham (2002); McCutchen (2006); Meadows (2017); Newton & Jesson (2025); Olson (2002)

Writing not only facilitates communication but also serves as a cognitive scaffold, strengthening essential thinking skills such as problem-solving, organization, and self-regulation (Graham & Harris, 2000; Tokuhama-Espinosa et al., 2024). As children write, they engage multiple brain functions, including executive functioning, and linguistic processing as

presented in Table 1. Over time, writing fosters cognitive flexibility by requiring children to synthesize ideas, make decisions, and reflect on their thought processes (Drijbooms et al., 2016; Guimaraes, 2023; Ruffini et al., 2024). Evidence cautions, however, that the relation between writing and cognitive processes is not uniform and can vary with task characteristics and difficulty, different children, and teacher techniques. For example, the Executive Function of self-regulation shows stronger effect sizes the more demanding writing tasks (Chandler et al., 2021).

Despite many schools of thought on the best ways to teach writing, some consensus has been found on the general order of processes. Writing development begins with foundational cognitive and motor skills that enable coherent text construction (Berninger & Winn, 2006; Graham & Harris, 2019). This often emerges naturally from drawing skills which tend to develop before letter writing (Mackenzie, 2024). There is a generally agreed upon path towards writing mastery in terms of skills and sub-skills. For example, according to research, young writers initially rely on transcription skills—letter formation and spelling—before progressing to complex tasks like argument development and revision (Graham & Harris, 2000; Ruffini et al., 2024). As these fundamental skills become more automatic, cognitive resources can be redirected toward higher-order writing processes, such as planning and revision (Drijbooms et al., 2016; Ruffini et al., 2024). This shift marks the beginning of metacognitive awareness, where children start evaluating their own writing and making intentional improvements (Graham & Harris, 2000; Graham & Harris, 2019; McCutchen, 2006).

Table 2 presents a simplified writing model for developing writers, outlining typical progressions in stages of writing and their associated cognitive processes. Unlike a rigid step-by-step sequence, these stages evolve with a child's development and experience

(Latham, 2002). Reading with children in the early years often begins the road to writing through example texts (Dorn & Jones, 2023), often progressing to the recognition of symbols, then the patterns and order of letters and letter combinations (Tokuhama-Espinosa, 2019). Before children form sentences, drawing often serves as an important scaffold for organizing and externalizing ideas, supporting the cognitive processes that underlie writing (Campbell & Cunningham, 2025), including matching forms and symbols to meaning. Once basic sentence formation is possible, research indicates that novice writers often begin drafting immediately upon receiving an assignment, focusing on idea generation rather than formalized planning (Cave, 2010; Graham & Harris, 2019; Latham, 2002; McCutchen, 2006). Instead of consciously structuring their text in advance, they retrieve relevant information from memory and adjust their ideas as they write (McCutchen, 2006). As a result, their revision process is embedded within drafting, as they tend to make spontaneous mid-sentence adjustments, such as modifying a word choice for clarity (McCutchen, 2006; Olive et al., 2009). These self-adjustments can be seen during writing through pauses, erasures, or verbal self-prompting (Latham, 2002; McCutchen, 2006; Olive et al., 2009). This behaviour stems from their developing executive functions which make it challenging to hold multiple writing components in working memory simultaneously and plan next steps (Harmey, 2021; Nicol & Pletcher,2025). Neuroscientific research provides insight into why planning differs for children: prefrontal cortex networks related to executive functions such as planning and organization, develop later than motor and linguistic regions (Berninger & Richards, 2002; Pöpplau & Hanganu-Opatz, 2024; Szaflarski et al., 2006; Uytun, 2018), and some more recent articles suggest that prefrontal cortex networks are dependent on motor cortex learning (Vinci-Booher et al., 2025). As children’s cognitive skills develop, they progressively shift from implicit to explicit planning, allowing for greater

structure and coherence in their writing (Latham, 2002; McCutchen, 2006). The literature emphasizes that gradual mastery of planning, organization, and reflection in writing not only strengthens composition skills but also lays the foundation for academic achievement and enhances adaptability in social learning processes (McCutchen, 2006; Graham & Perin 2007a; Ruffini et al., 2024). Different cognitive models of the writing process emphasize some stages of writing over others (e.g., Hacker, 2023; MacArthur, 2025; Ruffini et al., 2024), order them differently (e.g., Betz, 2022; Rakrak, 2025), include non-cognitive factors (e.g., Mercugliano et al., 2025), or include additional stages (e.g., the ThinkWrite Model which disaggregates the six stages mentioned in Table 2 below into 15 for precision in neural network identification [Tokuhama-Espinosa et al., 2024]). Here, in the Simplified Writing Model for Developing Writers (Table 2) we offer a concise review of what the current literature suggests facilitating reader understanding of networks potentially most impacted by ChatGPT in young children.

Table 2 Simplified Writing Model for Developing Writers

Writing Stage	Developmental stage		Cognitive function used	Cognitive function usage, short description
	Kindergarten	Primary School		
Prewriting	Engage in drawing and scribbling as precursors to formal writing. Begin to express ideas through pictures and verbal stories, starting to understand that written symbols carry meaning. Often	Start to initiate and sustain prewriting with less prompting. Begin planning writing more consciously, using drawings and symbols to	Inhibition, Self-regulation, Planning, Working Memory, Attention, Meta-linguistic Awareness,	Inhibition helps children resist distractions to focus on drawing/scribbling, supports focused planning and organization of thoughts. Self-regulation supports starting tasks, sustaining attention

Writing Stage	Developmental stage		Cognitive function used	Cognitive function usage, short description
	Kindergarten	**Primary School**		
	requires adult cues to stay on task.	organize thoughts before writing.	Critical Thinking	during drawing/ scribbling, and resisting distractions while coordinating early planning. Planning organizes ideas before writing. Working Memory holds these ideas for manipulation. Attention focuses on task relevance. Meta-linguistic Awareness understands language's structural aspects. Critical Thinking evaluates ideas for inclusion.
Knowledge building	At this stage, children use discovery learning to research and start building knowledge through storytelling and exploring familiar topics.	Primary school students start to use their reading experiences and classroom discussions as a foundation for their writing. They begin to explore and gather information on topics of interest, which informs their writing.	Cognitive Flexibility, Long-Term Memory (autobiographical, semantic emotional, procedural), Episodic encoding; Socio-affective mechanisms	Cognitive Flexibility allows shifting between different information sources for writing. Long-Term Memory sub-systems are important for recalling information from past readings and discussions to inform writing. Episodic encoding connects personal experiences to new learning. Socio-affective mechanisms support engagement through emotion and interaction.

Writing Stage	**Developmental stage**		**Cognitive function used**	**Cognitive function usage, short description**
	Kindergarten	**Primary School**		
Drafting	Start to form letters and words, attempting to write simple sentences or phrases, often using phonetic spelling. This stage involves translating their ideas into written form, transcribing ideas into form although in a very rudimentary way. Persistence may be limited, with effort needed to continue after starting.	Progress to writing sentences and short paragraphs, focusing on expressing ideas with coherent structures. Shows greater independence in sustaining attention and completing short texts.	Working Memory, Attention, Self-regulation, Long-term Memory (procedural, autobiographical, semantic), Theory of Mind, Problem-solving	Working Memory manages ongoing ideas. Attention maintains focus on narrative flow. Long-term Memory retrieves relevant information. Theory of Mind considers audience perspective. Problem-solving navigates narrative construction.
Reviewing & Revising	Young children focus more on expressing their ideas, and feedback from adults often initiates any revisions. Initially, this is an informal process, with children discussing their work with teachers and peers, and making minor adjustments based on feedback.	Children start to critically review and revise their work more systematically. They learn to refine their ideas and improve the clarity of their writing, often with guidance from teachers.	Attention Self-regulation, Critical Thinking, Theory of Mind, Meta-linguistic Awareness, Problem solving, Cognitive Flexibility, Critical Thinking	Attention to detail in reviewing content grows. Critical Thinking helps children evaluate narrative coherence, argument strength, the logical flow and clarity of the writing. Self-regulation sustains attention to feedback, manages frustration, and supports goal-directed revisions, helping children monitor progress and adapt strategies across drafts. Theory of Mind assesses audience understanding. Meta-linguistic Awareness

Writing Stage	**Developmental stage**		**Cognitive function used**	**Cognitive function usage, short description**
	Kindergarten	**Primary School**		
				checks language use and improves language precision. Problem-solving adjusts content for clarity. Cognitive Flexibility switches strategies for improvement. Critical Thinking refines arguments and narrative.
Editing	Editing is minimal and more adult-guided than self-directed due to limitation in focus, with attention directed mainly to basic error correction.	Gain skills to independently correct spelling, punctuation, and grammar errors, this skill continues to develop throughout primary school. Children become more persistent in error-checking and more capable of self-monitoring accuracy.	Inhibition, Attention (sustained), Long-term memory (procedural), Working Memory, Self-regulation, Meta-linguistic Awareness	Inhibition suppresses incorrect language use. Attention focuses on grammatical and spelling accuracy. Self-regulation resists the impulse to finish quickly and supports focus on accuracy during correction tasks. Meta-linguistic Awareness corrects language rules. Used to understand and apply the rules of language during self-editing.

Writing Stage	Developmental stage		Cognitive function used	Cognitive function usage, short description
	Kindergarten	**Primary School**		
Sharing	Share work by reading aloud or showing to teachers, classmates, and family, building confidence. It provides motivation and a sense of accomplishment, encouraging them to continue writing efforts.	Sharing and publishing become more formalized, with students presenting their work in class or for school projects. This stage provides an audience for their writing, offering valuable feedback and further motivation to refine their skills.	Theory of Mind, Critical Thinking	Theory of Mind anticipates audience reception. Critical Thinking evaluates final content suitability and impact.

NOTE: This table summarizes key components of writing stages and cognitive functions involved on each stage, focusing on shared or widely recognized points from the literature rather than providing an exhaustive list. For example, the grouping of cognitive functions aligns with documented frameworks but simplifies some categorizations to emphasize commonalities across sources. The table is based on Flower and Hayes model, DIEW model, and analyzed research by Tokuhama-Espinosa and colleagues (2024), McCutchen (2006), Ruffini and colleagues (2024), and Latham (2002, chapters 4 and 6) to find six common points common to all.

Importance of Effective Instructional Design During the Writing Process

Writing offers substantial cognitive benefits, but becoming a proficient writer requires explicit instruction – it does not occur “naturally” from exposure to text (Latham, 2002). Drawing serves as a bridge from ideas to print, but it, too, often requires guidance in the early years (Campbell & Cunningham, 2025). Without guidance, specific abilities like planning and self-regulation are frequently underused, which leads to poorly structured drafts and limited revisions (Graham & Hebert, 2011; Santangelo et al., 2007). In fact,

empirical studies show that teaching students specific strategies for planning and self-monitoring significantly improves their writing performance (Graham & Perin, 2007a).

Traditionally, writing instruction has taken a product-focused approach. Teachers prioritized the final text—its accuracy, grammar, and format—over the cognitive processes of writing (Campbell, 2023; Hairston, 1982; Tokuhama-Espinosa et al., 2024). One consequence was the popularity of rigid templates (e.g., the five-paragraph essay), which limited students' cognitive engagement with the writing process (Applebee, 2017; Hairston, 1982; Leigh & Ayres, 2015). Writing was treated as a linear, one-off task: students were often expected to produce a polished draft in one go, leaving little room for revising or rethinking ideas (Hairston, 1982; McCutchen, 2000; Olive et al., 2009). Without multiple drafts or revisions, students can miss critical opportunities to refine their arguments and expand their thinking (Graham et al., 2024, McCutchen, 2000).

In contrast, the process-oriented approach places more emphasis on the stages of writing as dynamic and recursive activities essential for cognitive development and not only the means to a product. This perspective views writing as an evolving process, where learning occurs through iterative steps of exploration, inquiry, and discovery at each stage (Calkins & Ehrenworth 2016; Leigh & Ayres, 2015; Murray, 1968). Initially inspired by Vygotsky's work *Thought and Language* (Vygotsky, 1962), this shift from a product-focused to a process-oriented view of writing, which emphasizes inquiry and discovery, marks a radical transformation in writing pedagogy. Encouraging students to develop their ideas step by step, with guidance like that of professional writers that coaches thinking, strengthens both engagement and writing quality (Atwell, 1987; Bean & Melzer, 2021; Graves, 1983; Hairston, 1982; Leigh & Ayres, 2015; Murray, 1968). The literature emphasizes the pivotal role of teachers in creating a supportive writing environment that promotes reflective practice

and systematic skill development (Friedrich 2019; Goldstein, 2017; Kervin et al., 2020; National Writing Project, 2017).

By incorporating instructional strategies, such as guided feedback in which there is dialogic exchange around suggested changes; think-aloud techniques where students verbalize how they are approaching the writing; and scaffolding where learners are nudged to work just beyond their current abilities, educators can help children transition from implicit, reactive planning—characteristic of product-focused instruction—to more deliberate, structured approaches that define process-oriented learning (Corden, 2000; Graham & Perin, 2007a; Graham & Perin, 2007b; Kellogg 2008; Santangelo et al., 2007). Those process-oriented instructional strategies align with Vygotsky's concept of a Zone of Proximal Development (ZPD), defined as the gap between what a learner can do independently and what they can achieve with expert guidance (McLeod, 2024). By focusing on tasks that stretch learners' current capacities, educators enable students to engage in challenging writing activities (Kellogg, 2008). This type of engagement stimulates neural plasticity (Gutshall & Kelly, 2021; Peng et al., 2022), fosters cognitive flexibility (Drijbooms et al. 2016; Ruffini et al., 2024; Tal & Shaul, 2024; Vygotsky, 1978), and builds resilience through sustained effort (Dweck, 2006; Yeager & Dweck, 2012).

Empirical studies demonstrate that students taught through process-oriented approaches produce higher-quality writing with improved content organization compared to those under product-focused instruction (Graham & Sandmel, 2011; Graham et al. 2012). Guided feedback enhances metacognitive skills by encouraging students to reflect on their writing decisions (Graham & Harris 2019; McCutchen, 2006; O'Brien-Moran & Soiferman, 2010). Studies indicate that children who receive structured guidance in pre-writing—such as outlining and goal-setting—demonstrate improved text coherence and idea organization

(Cave, 2010; De La Paz & Graham, 1997; Graham & Perin, 2007a; Hooper et al., 2006). Think-aloud techniques support working memory and cognitive control by modelling the reasoning behind writing tasks (Bereiter & Scardamalia, 1987, López et al. 2017). Scaffolding offers structured support, promoting resilience and adaptability by progressively challenging students within their Zone of Proximal Development (Vygotsky, 1978; Kellogg, 2008; Graham & Harris 2019; Tsiriotakis et al. 2017).

Hence guided practice fosters cognitive skills such as higher-order thinking (Bangert-Drowns et al. 2004; Latham, 2002; Vâlcea & Pavel, 2021). A reflective, inquiry-based environment complements this by embedding writing practices into students' regular learning routines (Latham, 2002; Vâlcea & Pavel, 2021). These research findings highlight the necessity of early writing support to ensure children develop the skills required for advanced cognitive and literacy tasks later in life (Graham & Perin, 2007b; Graves 1983).

Writing as a Scaffold for Other Learning

Writing is a unique mode of learning that engages students in active thinking unlike any other form of communication (Emig, 1977). The premise of *writing to learn* is that engaging in writing fosters deeper content engagement and enhances critical thinking across disciplines (Bangert-Drowns et al., 2004; Emig, 1977), a concept strongly supported by empirical evidence (Graham et al. 2020). When students write about what they are learning – be it a story in literature or an observation in science – they engage in meaning-making that improves retention and understanding (Bangert-Drowns et al. 2004; Cave, 2010; Cheung et al., 2025; Myhill et al., 2021). This is true for even the youngest emergent writers. Writing forces emergent writers to rephrase content in their own words and connect new information to prior knowledge, which strengthens memory consolidation (Graham et al., 2020; Moreno & Tabullo, 2023; Rocha et al., 2022) and promotes higher-order thinking

(Bangert-Drowns et al., 2004; Basar & Batzur, 2025). In fact, a comprehensive meta-analysis reported that students who wrote about content showed significantly greater learning gains than those who did not, across subjects ranging from math to social studies (Graham & Hebert, 2011). Those benefits of writing-to-learn activities were evident in elementary-aged children as well as older students, underscoring that even early writers profit from using writing as a learning tool (Graham et al., 2020). Even the youngest students were shown to use considerably higher order thinking skills when guided in picture book review (Munar et al., 2022). Research supports using writing as a scaffold, showing that it enriches students' learning experiences by increasing active engagement with content (Bangert-Drowns et al., 2004), improving conceptual understanding (Graham & Hebert, 2010), and facilitating deeper processing and integration of knowledge across disciplines (Klein & Boscolo, 2016). This active cognitive engagement through writing significantly enhances overall cognitive development (Graham et al., 2020). For example, when students write about content they have learned in subjects like literature, science, or philosophy, they process and articulate that knowledge more deeply, which in turn strengthens their comprehension and enhances their ability to tackle complex ideas (Günel et al., 2009; Hand & Prain 2012; Meadows, 2017; Torrance et al., 2007). Additionally, findings indicate that writing practice benefits second-language learners further by enhancing cognitive skills such as metalinguistic awareness and working memory, thereby supporting their overall intellectual development across disciplines (Peng et al., 2022).

Educators have leveraged cognitive benefits of the write-to-learn approach through writing-across-the-curriculum initiatives that embed writing tasks in varied disciplines (McLeod et al. 2001). Rather than confining writing instruction to language arts, teachers employ writing in math journals, science notebooks, and learning logs to scaffold thinking in

those domains (Basgier, 2025; O'Brien, 2022;). Studies show that writing across the curriculum can yield improvements beyond the obvious writing skills (Bangert-Drowns et al., 2004; Sturk, 2023) and into increased content understanding. For example, in a general education biology class, students who routinely wrote analytical essays about lab topics showed greater critical thinking gains than those who only took tests (Quitadamo & Kurtz, 2007). Writing across the curriculum with younger children also reinforces basic cognitive and social emotional skills. Kennedy and Shiel (2025) highlight multiple benefits of using approaches such as Graham's *Writer(s)- within-Community Model* (2025) in which children take on the roles of "writers, collaborators, mentors and teachers" (Graham, 2025, p. 18) to extend their writing through perspective-taking. By externalizing their thought processes on paper, children effectively create a scaffold for clarifying complex ideas and reflecting on their own learning (Olson, 2002). In practice, *writing to learn* transforms writing from a language exercise into a cross-disciplinary strategy for active learning and knowledge construction (Applebee, 2017).

As the literature demonstrates, writing is a cognitively demanding process that strengthens executive functions, memory, and metacognitive awareness through planning, revision, and reflection. When supported by structured instruction, writing helps children develop flexible thinking and problem-solving. It also serves as a bridge across disciplines, enhancing content learning and knowledge transfer.

What Impact Does ChatGPT Have on Cognitive Development among Developing Writers?

Given that children's cognitive skills are still developing, particular care is needed when integrating AI into their writing practices. While writing independently strengthens core

cognitive functions, the growing use of ChatGPT raises questions about whether these gains are reinforced or displaced. This section examines ChatGPT's dual role as both a scaffold and a shortcut, considering evidence of cognitive support, risks of overreliance, and the developmental conditions that shape its impact on young writers.

ChatGPT as a Cognitive Support Tool in Early Writing

ChatGPT is often perceived by students as a tutor or knowledgeable peer that can support early-stage writing (Levine et al., 2025) especially in bilingual writing (Yin, 2024). Learners reported using the tool to access explanations, topic suggestions, or structural help when unsure how to begin a task (Bašić et al., 2023; Levine et al., 2025). Wang (2024) observed that this support was especially valued during times when teachers or peers were unavailable, with students describing ChatGPT as a 24/7 writing companion. ChatGPT has been used to help students organize content, generate outlines, and receive structured guidance during early writing stages, with several authors including Yin (2024) and Alsaedi (2024) noting that these functions closely resemble those provided by a human peer or tutor. For English as a Foreign Language (EFL) and English as a Second Language (ESL) learners, in particular, ChatGPT was described as a personal tutor assisting with basic writing structure and conceptual planning (Alsaedi, 2024; Athanassopoulos et al., 2024). In the context of younger learners, ChatGPT has also been found to support language development by engaging children in interactive, age-appropriate dialogues that enhance both conversational fluency and foundational writing skills (Luo et al., 2024). The prevalence of ChatGPT use, especially with young learners, brings into question the impact on cognitive skills related to writing.

In cognitive models of writing, planning, regulation, and task initiation are recognized as executive functions (Ruffini et al., 2024). Studies show that such processes are activated

when learners engage with ChatGPT to initiate, organize, and regulate early-stage writing (Alsaedi, 2024; Luo et al., 2024). Specifically, ChatGPT use has been shown to support cognitive processes such as planning and regulation (Alsaedi, 2024; Luo et al., 2024). These processes align with executive functions identified in child writing development, including working memory, inhibition, and cognitive flexibility (Ruffini et al., 2024), which are now seen to be at risk, according to some researchers (e.g., León- Domínguez, 2024), while being touted by others as beneficial (e.g., Pergantis et al., 2025). Some learners demonstrated increased independence when using ChatGPT to initiate and organize writing tasks (Alsaedi, 2024; Evmenova et al., 2024). These observed behaviors, including task initiation and sequencing, align with early self-regulatory development as described in child writing models (Ruffini et al., 2024). Even though ChatGPT can support thinking in writing, researchers have also raised concerns about what might be lost if it is misused or overused.

Potential Cognitive Risks

After reviewing articles published between 2022-2025, the review of the literature revealed four recurring patterns of concern regarding how ChatGPT use might influence the cognitive development of young writers. These relate to (a) reduced engagement of executive functions due to “cognitive offloading” (e.g., Armitage & Gilber, 2025; León-Domínguez, 2024), (b) limited opportunities for critical thinking (e.g., Shah & Asad, 2024; Szmyd & Mitera, 2024), (c) missed cognitive growth due to writing disengagement (e.g., Chen et al., 2024; Kosmyna et al., 2025), and (d) diminished control over revision and authorship (e.g., Han et al., 2024; Lueg, 2024). Each concern is described below.

Executive Function Underuse. Although much of the current literature emphasizes the practical applications of ChatGPT, due to the newness of the phenomena, there are no studies that have examined its long-term cognitive implications (Bai et al., 2023; León-

Domínguez, 2024). Bai and colleagues (2023) and León-Domínguez (2024) suggest that by reducing cognitive load, which has short-term benefits allowing for more energy to more complex tools, AI tools may interfere with the long-term development of executive functions essential to writing, including goal-setting, self-monitoring, and flexible reasoning. The concept of cognitive offloading in which humans delegate mental tasks to external systems, may offer short-term efficiency but risks underutilizing core cognitive processes such as planning, inhibition, and regulation (Machidon, 2025) that need rehearsal for executive functions to be developed successfully. While these tools may temporarily support performance on cognitively demanding tasks, they do not appear to strengthen underlying executive functions (León-Domínguez, 2024).

Emerging EEG evidence with adults shows that LLM-assisted composing shifts processing toward a more automated, scaffolded mode and "restructure[s] not only task performance but also the underlying cognitive architecture" (Kosmyna et al., 2025, p. 136), which is consistent with concerns about underusing internal executive control. From a neurological perspective, the brain is highly plastic, meaning it can adapt its structure in response to new tools and learning contexts (León-Domínguez, 2024). According to León-Domínguez (2024), these tools occupy what is known as a "neuronal niche," where existing brain circuits are reused or redirected to support external aids like ChatGPT. This process may gradually influence how certain cognitive functions are developed and exercised (León-Domínguez, 2024). As a result, some researchers caution that repeated reliance on AI systems may leave learners less prepared for situations that demand flexible reasoning and independent thinking (Yavich, 2025). This may have different and potentially worse effects on younger learners than on adults who have already established core thinking processes related to language. Young children, in contrast, have yet to develop a strong foundation for

core cognitive processes, making them more vulnerable to gaps that may develop based on ChatGPT's "help." Both Hebb's "use it or lose it" principle (1949) and radical neuroconstructivist theory (Tokuhama-Espinosa & Borja, 2023) stress that the brain is shaped by repeated practice: connections are reinforced when activated and pruned when neglected. From this perspective, limited engagement of executive functions during writing with AI could gradually weaken the neural foundations needed for independent, higher-order thought.

Reduced Critical Thinking Effort. Research indicates that when students rely heavily on ChatGPT, they may bypass opportunities to engage in creative thinking and analytical reflection, higher-order skills essential for writing development (Alsaedi, 2024; Xu, 2025). Tate and colleagues emphasize that "writing is hard; thinking is hard" (2023, p. 10), underscoring that struggle is a necessary part of building reasoning skills. Several studies have raised concerns that the habitual use of AI to streamline writing tasks may promote surface-level engagement, particularly when students rely on AI for immediate answers rather than forming their own judgments about content (e.g., Kosmyna et al., 2025; Levine et al., 2025; Marchetti et al., 2025). In an empirical multi-session essay study, LLM users struggled to recall and quote from their own essays, suggesting critical engagement with content was bypassed (Kosmyna et al., 2025), and even self-generated ideas were more easily forgotten. When AI is used to avoid cognitive effort, it may compromise the quality of decision-making and reasoning over time (Bai et al., 2023; Luo et al., 2024), as well as move learners to disengage from the writing process altogether.

Missed Cognitive Growth Through Writing Disengagement. Motivation to engage in writing tasks is not only essential for learning but also plays a foundational role in the development of cognitive functions such as executive control, metacognitive awareness, and

reasoning, which evolve through repeated writing practice (Graham & Harris, 2000; Ruffini et al., 2024). Research shows that when students consistently use AI to complete writing tasks, they may become less motivated to engage critically with their work, especially when they rely on AI for convenient answers instead of pursuing deeper understanding independently (Alsaedi, 2024; Luo et al., 2024). This disengagement may prevent them from practicing essential stages such as planning and revising, which are central to writing development (Campbell, 2023). Alsaedi (2024, p.48) warns that this type of disengagement may lead to "learning loss"—not merely a reduction in output quality, but a failure to build writing-related cognitive skills through practice, which is a prerequisite for higher order thinking. Without consistent engagement in these writing processes, students may miss opportunities to strengthen executive functions such as planning, inhibition, and sustained attention. This concern is particularly acute for younger writers, as these systems are constantly maturing and require repeated cognitive activation to develop effectively (Drijbooms, 2016; Ruffini et al., 2024). Over time, this may compromise the development of self-regulatory habits and reflective writing strategies, ultimately affecting skill development across writing stages (McCutchen, 2006; Ruffini et al., 2024). Scholars emphasize the importance of adult guidance in mitigating these risks during early education (Luo et al., 2024).

Erosion of Writing Voice and Metacognitive Control. A fourth and final cognitive risk highlighted in the literature is a potential conflict between fluency and authenticity when students write with AI support (Arseven & Bal, 2025; Wang, 2024). Wang (2024) noted that students faced a dilemma between "sounding better or sounding like me" (p. 15), a tension that may be amplified in younger writers still developing their authorial identity. While Wang's research considered university writers, the implications for younger writers who are still struggling to find their own voices is of even greater concern. Levine and colleagues (2025)

observed that adolescent students often accepted ChatGPT's suggestions without question, replacing full sections of text without reflecting on how those edits aligned with their original rhetorical intent. Empirical EEG evidence reinforces this concern: adults writing with ChatGPT reported lower ownership of their texts and showed weaker memory consolidation, reflecting diminished agency over their writing (Kosmyna et al., 2025). In the case of very young learners, there is the possibility that one's own voice can be altogether overshadowed by ChatGPT recommendations. In the absence of instructional scaffolding that fosters reflective engagement, wholesale adoption of AI-generated text risks compromising the development of both metacognitive and self-regulatory skills (Arseven & Bal, 2025). Metacognitive risks include reduced capacity to critically evaluate ChatGPT's suggestions or decide which edits best align with the writer's intent (Levine et al., 2025). Self-regulatory risks involve diminished independent control over writing choices, such as deciding when to revise, what to revise, and why, all of which are core elements of executive functioning critical to writing development (Wang, 2024).

Potential Cognitive Benefits

Despite valid concerns, several studies point to cognitive benefits when ChatGPT is used in well-structured, reflective writing environments. The review of the literature identified four key areas of cognitive benefit associated with ChatGPT use in writing tasks. These include (a) activation of executive functions during planning and revision (e.g., Pergantis et al., 2025; Rileyet al., 2025), (b) strengthening of critical thinking and metacognitive reflection (Hsiao et al., 2025; Levin et al., 2025), (c) increased cognitive focus through reduced strain on surface-level tasks (e.g., King & Garramoone, 2025; Suriano et al., 2025) , and (d) improved motivation, confidence, and persistence in writing (e.g., Echiverri, et al., 2025; Kızıltaş, 2025); .

Executive Function Activation. Executive function processes such as planning and goal monitoring are essential to writing development (Ruffini et al., 2024), and while some found Executive Function underuse, others noted that much depends on *how* ChatGPT is used. Wang (2024) and Levine and colleagues (2025) suggest that ChatGPT can support Executive Functioning processes when students engage with the tool critically. For example, Wang (2024) found that students, rather than bypassing cognitive effort, could use ChatGPT to reflect, revise, and explore their ideas more carefully. Students reported that the tool helped them think further about their writing and move beyond surface-level responses. In a separate study, these same learners “attempted to seize new learning opportunities” by refining their arguments and experimenting with revisions (Wang, 2024, p. 16). Similarly, Levine and colleagues (2025) observed that high school learners refined multiple drafts, revisited earlier outputs, and monitored their progress to align with writing goals. This pattern of behavior reflects planning and task regulation—core aspects of executive functioning (Arseven & Bal, 2025; Levine et al., 2025) that can be developed in classroom settings if planned. For example, when students were exposed to several AI-generated versions of a paragraph or outline, thy could use these “contrasting cases” to evaluate structural differences and plan revisions (Athanassopoulos et al., 2023; Wang, 2024). Yin (2024) similarly found that integrating ChatGPT into structured writing tasks helped guide learners toward a thinking-oriented process, supporting planning and goal management. Scaffolded use of ChatGPT in pre-school or elementary classrooms has taken place using similar strategic use of the tool. For example, moving from oral storytelling to seeing one’s words on paper can have a powerful impact on young learners (Chin et al., 2024) and encourage a reflection on the logical placement of events and characters which develops the planning aspect of executive functions. While it is not known what effects this would have on young

children, one can imagine how kids could potentially explore multiple outcomes in story scenarios, expand on creative options in writing contexts (*"what would this look like if this was a jungle and not the woods?"*), vocabulary (*"what's another word for…?"*).

Critical Thinking & Metacognitive Reflection. Current research indicates that prompting ChatGPT requires learners to engage in metacognitive reflection, particularly when they identify informational needs and refine their prompts to generate more purposeful responses (Levine et al., 2025; Tate et al., 2023). When students approach the prompting process intentionally, rather than relying on generic assistance, they actively practice self-monitoring and cognitive clarity during planning and revision (Alsaedi, 2024; Levine et al., 2025). Interestingly enough, this process is changed when writing became the ability to form a good prompt, as occurs with writing with ChatGPT. According to Yin (2024), the use of ChatGPT in a structured writing task led to observed improvements in students' critical-thinking performance, as assessed using a rubric adapted from Ennis's taxonomy of critical thinking (1991). These gains were reflected in the clarity of reasoning, justification of claims, and coherence of written arguments. Tate and colleagues (2023) introduced the concept of using ChatGPT as a "tutee," in which students identify flaws in the AI's output and corrected them, an exercise that strengthens both critical thinking and metacognitive awareness. This suggests that not only formatting a prompt was helpful, but that then comparing that prompt response to one's own logic was also helpful. Students who compared ChatGPT outputs with their own work demonstrated deeper reflection on tone, structure, and rhetorical choices (Arseven & Bal, 2025; Levine et al., 2025). Similarly, evaluating multiple AI-generated responses helped learners identify stylistic features and persuasive strategies, reinforcing evaluative thinking (Levine et al., 2025). This strategy, referred to as using "contrasting cases," has been shown to promote planning and rhetorical reflection in writing

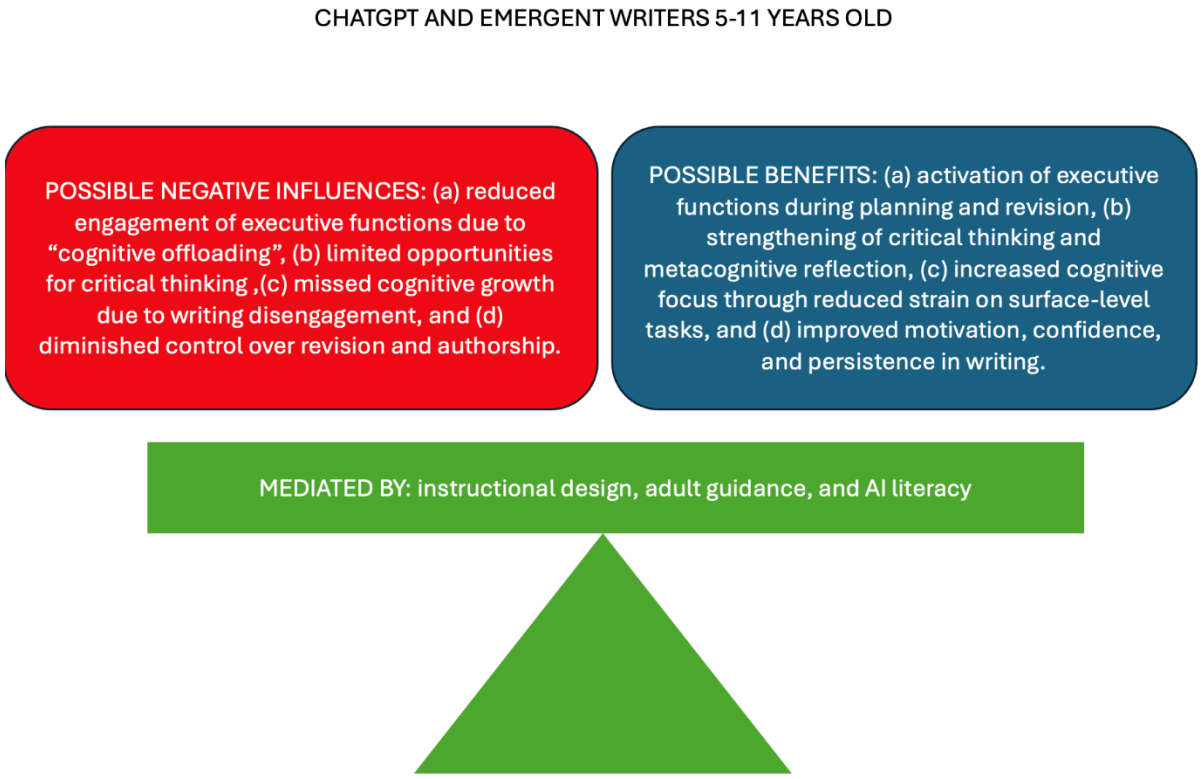
(Athanassopoulos et al., 2023; Wang, 2024). With younger children, some researchers have found that using ChatGPT as a co-writer can help children kindergarten through fifth grade re-think premises, challenge stereotypes, and critique ChatGPT suggestions when guided by teachers (La Mear & von Gillern, 2025). Using ChatGPT successfully as a writing companion can reinforce the development of meta-cognitive skills, as shown in LeMear and von Gillern's work, but only when scaffolded by teacher prompts.

Increased Cognitive Focus and Reallocation. In addition to supporting planning and reflection, ChatGPT may also help students reallocate cognitive resources by reducing the mental effort required for surface-level tasks such as grammar and syntax (Ghafouri et al., 2024; Wang, 2024). When students used the tool to handle these "lower-level" concerns, they reported being better able to focus on organizing ideas and improving the structure of their arguments (Wang, 2024). This follows other writing advice by those who suggest freewriting – including writing without concern for spelling or grammar – can free up creative focus and allow richer ideas to surface. Ghafouri and colleagues (2024) similarly found that adult second-language learners experienced reduced cognitive strain when ChatGPT supported sentence-level revision. Although these findings emerged from research with more experienced learners, the same mechanism—freeing up cognitive capacity—may also benefit developing writers who struggle to manage surface-level demands. Levine and colleagues (2025) also observed that students used ChatGPT to address both local issues (e.g., grammar and vocabulary) and global concerns (e.g., argument coherence and organization). These patterns suggest that ChatGPT can function as a cognitive support tool by enabling students to prioritize higher-order writing tasks. Yet findings indicate its impact is greatest on performance outcomes, with only moderate effects on higher-order thinking and benefits that require instructional support to compensate for ChatGPT's limited critical

analysis and creativity (Wang & Fan, 2025). Some research on younger learners has also shown that initial rejection of writing practices could be made more attractive by incorporating ChatGPT, reducing the energy used to resist writing activities and enhancing motivation in reluctant writers (Gultekin et al., 2025). Gultekin and colleagues (2025) showed that ChatGPT could be used to draw-in reluctant learners, thanks to its novelty and way it changed the approach to writing by beginning with speech through language rather than common drills in traditional settings.

Motivation, Confidence, and Writing Persistence. Beyond cognitive task reallocation, several studies highlight the emotional and motivational benefits of ChatGPT use in writing tasks. Alsaedi (2024) reports that brainstorming ideas and exploring diverse linguistic styles (for example, variations in tone, word choice, or sentence structure) with ChatGPT enhanced students' creativity and engagement. In a related finding, Ghafouri and colleagues (2024) observed that when students used ChatGPT to revise iteratively and receive non-judgmental feedback, their motivation and self-regulatory behaviour improved. This iterative use contributed to greater persistence in writing and helped students reflect more actively on their progress, fostering metacognitive control (Ghafouri et al., 2024). Although students acknowledged potential risks such as learning loss, Wang (2024) found that many also viewed ChatGPT as a tool for expanding expression and building writing confidence. Young children's motivation for writing has been shown to increase when using ChatGPT as a first reviewer on work, as the generally kind and encouraging tone matched with timely and culturally relevant feedback can give learners confidence (Arseven & Bal, 2025; Bushnell, 2025). Figure 2 summarizes the balance of possible positive and possible negative influences of ChatGPT on emergent writers 5-11 years old.

Figure 2. Possible Negative Influences and Benefits of ChatGPT Use with Emergent Writers 5-11 Years Old.



NOTE: Summary of the literature findings on the possible negative effects and the possible benefits of using ChatGPT with young children, which was found to be mediated by good instructional design, adults guidance, and on-going AI literacy.

Developmentally Appropriate Integration and Adult Oversight

The question of when and how to integrate AI tools like ChatGPT into education has significant cognitive implications for young learners (Luo et al., 2024; Tate et al., 2023). Luo and colleagues (2024) raise concerns that premature exposure could inhibit imagination, critical thinking, and the development of broad world knowledge. Others also point to the brain's need to rehearse pathways for key cognitive functions, which might be compromised with overuse of ChatGPT in the earliest stages of learning. According to Tate and colleagues

(2023), building foundational writing skills independently remains essential before introducing AI support, in the same way that learning manual calculation skills precedes calculator use. They argue that premature AI reliance risks bypassing crucial cognitive stages (Tate et al., 2023). To address this, Tate and colleagues (2023) emphasize that educators should scaffold the gradual integration of AI, ensuring that core writing skills are strengthened before technological assistance is introduced. This adds a level of cognitive complexity in which the learners need to be conscious of the learning steps. This is akin to requiring learners explain the math behind the formula before using a calculator. This reveals a long-term challenge in education, which is the "why" children often ask: *Why should I learn that boring task?* Successful use of ChatGPT, then, seems to hinge on teacher expertise even more than already needed. Developmentally, scaffolded use aligns with the Zone of Proximal Development (ZPD) (Vygotsky, 1978), where adult mediation helps bridge what learners can do independently and what they can achieve with support. Skipping foundational stages too early, such as planning or drafting, may leave gaps in the neural architecture needed for more advanced writing competencies (Ruffini et al., 2024; Tokuhama-Espinosa et al., 2024).

Literature examining early childhood AI use highlights structural limitations of ChatGPT that may pose challenges for young learners (Luo et al., 2024; Tate et al., 2023). Luo and colleagues (2024) note that effective engagement with ChatGPT depends on students' ability to formulate precise prompts, a skill still under construction in early writers, and that this kind of prompting must be modelled well by teachers to be successful (LaMear & von Gillern, 2025). Tate and colleagues (2023) argue that AI tools may address mechanical aspects such as grammar, syntax, or phrasing without reinforcing deeper cognitive skills, unless foundational writing capacities are firmly established, and clear

prompting questions can be rehearsed (Lindrupt et al., 2025). In broader educational contexts, Su and colleagues (2023) emphasize that ChatGPT cannot independently foster critical thinking, as it is reactive and unable to initiate guiding questions to scaffold reasoning processes, though some educational applications—such as Khanmigo, a GPT-4–powered tutoring system developed by Khan Academy—try to address this by beginning interactions with Socratic questioning through a structured prompting layer (Khan, 2024). Yin (2024) similarly notes that learners require structured guidance (for example, step-by-step scaffolds or teacher-designed prompts) to interact with the tool productively and meaningfully. This challenge is especially salient for younger learners, whose developing language skills make it difficult to formulate effective prompts—an essential prerequisite for meaningful ChatGPT interaction (Luo et al., 2024). Emerging empirical evidence from EEG-based essay study demonstrates that when adults used ChatGPT without guidance, both neural activity and behavioral measures of ownership declined, a pattern that reinforces the need for structured support when younger learners engage with AI (Kosmyna et al., 2025). To date, Khanmigo's prompting interface is being refined to better support learners in formulating initial prompts, while the use of Socratic questioning through ChatGPT remains under assessment (Blasco & Charisi, 2024). Without such support, the tool may not contribute effectively to writing development. Athanassopoulos and colleagues (2023) and Tate's research team (2023) emphasize that ChatGPT lacks dialogic feedback, limiting its capacity to support writing development through instructional interaction. The tool also does not ask clarifying questions or adapt its responses to student misunderstandings (Tanchuk & Taylor, 2025; Tate et al., 2025). Normally, as Tate and colleagues (2023) point out, AI-generated feedback often fails to reflect rhetorical goals, such as student intent, audience awareness, or genre expectations—elements routinely modelled by human instructors. Both Tate and colleagues

(2023) and Athanassopoulos and colleagues (2023) caution that without targeted instructional framing, ChatGPT does not effectively support writing as a form of communication. As of this paper's writing, there have been no empirical studies on Khanmigo and writing.

To address the limitations of AI-based writing tools, researchers consistently emphasize the importance of adult scaffolding (Athanassopoulos et al., 2023; Beck & Levine, 2023; Su & Yang, 2023), especially for very young learners. Su and Yang (2023) argue that adults must act as mentors, guiding learners through the evaluation of ChatGPT's output and helping align AI use with educational goals. Beck and Levine (2023) similarly highlight that teacher mediation is necessary to support the development of foundational writing skills, especially in classrooms where AI tools become increasingly standard. Khanmigo's approach seems to address these concerns as it tries to mimic a personal tutor for every child, but there is yet little evidence that the guardrails needed can be included by anyone else except the teacher (Williamson et al., 2024). Teacher support plays a critical role in preventing misuse. For example, Athanassopoulos and colleagues (2023) found that unsupervised student use led to confusion or inappropriate application of AI-generated content. Levine and colleagues (2025) observed that without structured guidance, students sometimes accepted entire AI-generated edits without evaluating their alignment with rhetorical purpose. To mitigate this, teachers were encouraged to "make thinking visible" by prompting students to reflect on why and how they used ChatGPT suggestions (Levine et al., 2025, p. 456). Collectively, these findings reinforce the need for structured teacher involvement to promote metacognitive regulation and writing independence (Athanassopoulos et al., 2023; Beck & Levine, 2023; Levine et al., 2025; Su & Yang, 2023).

Taken together, the literature underscores a paradox: ChatGPT may enhance focus, motivation, creativity, and scaffolding for idea generation, yet it may also promote disengagement, diminish executive function use, weaken metacognitive control, and foster dependence. Whether it functions as a tool for growth or as a shortcut that undermines cognitive development of basic skills in young children depends on how it is integrated into learning. A fuller comparison of described benefits and drawbacks is developed in the Analysis section.

What Is the Impact of ChatGPT on the Writing Process of Developing Writers?

While the previous section examined the cognitive underpinnings of ChatGPT use, this section turns to how the tool influences students' writing behaviors across stages of the writing process. It reviews AI's role in supporting early drafting, revision, and self-editing, as well as its effect on motivation and writing confidence. Finally, it addresses the growing need to embed AI literacy in writing instruction to prepare students for AI-integrated learning environments.

Multi-Stage Writing Support and Its Effects

Writing develops over time and multiple stages both mentally as well as in terms of products. Similar to the literature on other ChatGPT topics, there are both benefits as well as drawbacks to its use. Research highlights that ChatGPT supports developing writers across three main areas: (a) personalized learning (e.g., Bai et al., 2023; Ghafouri et al., 2024; Luo et al., 2024; Tseng & Warschauer, 2023); (b) instructional feedback across writing stages (e.g., Dwivedi et al., 2023; Ghafouri et al., 2024; Levine et al., 2025; Tseng & Warschauer, 2023); and (c) evolving approaches to writing assessment (e.g., Campbell, 2023; Dwivedi et al., 2023; Ghafouri et al., 2024; Levine et al., 2025).

Personalized learning. ChatGPT's personalized learning potential includes not only integrated grammar correction, paraphrasing, and translation tools (Tseng & Warschauer, 2023), but it also adjusts to individual learner needs, even at the youngest age (Kasinidou, 2024). More broadly, it has been described as a tool that can enhance access to writing support and enable individualized learning paths (Bai et al., 2023; Luo et al., 2024). While beneficial to all learners, these features are especially valuable for multilingual learners, who demonstrate gains in vocabulary use and writing fluency during AI-supported revision (Athanassopoulos et al., 2023). In a study of EFL writers, Alsaedi (2024) found that students used ChatGPT to generate outlines and example texts that modelled effective composition structures, suggesting that use of worked models is one way ChatGPT can embrace writing experience. The tool's efficiency in handling mechanical concerns such as basic grammar and spelling errors also allowed students to redirect cognitive resources toward coherence and content development (Alsaedi, 2024).

ChatGPT has also been shown to support writing instruction by reinforcing feedback across multiple stages of the process. In teacher-guided classrooms with older students there is evidence ChatGPT can assist with brainstorming, outlining, drafting, and revising while maintaining independent control over planning and refinement (Levine et al., 2025; Wang, 2024). Wang (2024) observed that learners engaged with the tool to revise global elements such as structure and coherence, as well as micro elements including sentence-level fluency and vocabulary. Students also explored alternate phrasings and rhetorical tones, using ChatGPT output to make stylistic decisions and deepen their engagement with revision (Levine et al., 2025). In secondary classrooms, there is evidence ChatGPT is frequently used in place of grammar checkers and online search engines for prewriting and self-editing (Levine et al., 2025). Some researchers have suggested that ChatGPT is now

being used not only to support revision but also to help students draft early versions of their work in collaboration with instructors, potentially reducing feedback delays while preserving student agency (Dwivedi et al., 2023). In research on younger learners, personalization and timely access to feedback were two of the most attractive aspects of ChatGPT (Bushnell, 2025). In a study of L2 learners, Ghafouri and colleagues (2024) reported that students interacting with ChatGPT across the planning, drafting, and revising stages developed stronger writing strategies and expressed increased confidence in their ability to complete writing tasks. It should be noted that there are no studies we could find on young children from a neuroscience perspective and actual use of ChatGPT as of this paper's writing, making it difficult to explain the consequences of these uses on long-term cognitive development.

Lastly, some researchers suggest that ChatGPT is prompting educators to reconsider how writing is assessed, particularly in terms of planning, iteration, and authorship (Campbell, 2023; Levine et al., 2025). Rather than emphasizing only final products, some educators are beginning to foreground the process of idea generation and revision as meaningful indicators of writing development (Campbell, 2023). With younger learners, research shows that teachers have successfully used ChatGPT to motivate uninterested learners to engage with writing processes, such as converting students' drawings into stories (Fusco, 2024; Hariffadzillah, 2023; Lindrup et al., 2025). This pedagogical shift is reflected in classroom studies where ChatGPT is being used to support formative feedback and iterative revision (Ghafouri et al., 2024). While current studies confirm that students engage with ChatGPT across the writing process, the quality and depth of this engagement often depend on contextual factors such as instructional support and task design (Ghafouri et al., 2024; Levine et al., 2025; Wang, 2024).

Affective Dimensions of ChatGPT-Supported Writing: Motivation, Confidence, and Persistence

Beyond technical and structural support, ChatGPT's impact on writing is also shaped by students' emotional responses, including how confident or anxious they feel during the process. Several studies report that ChatGPT may positively influence student motivation, especially when used for brainstorming and early drafting (Alsaedi, 2024; Levine et al., 2025), not only due to the novelty of the tool, but also due to the soothing and non-judgmental tone, often accompanied by positive phrasing and encouraging words (Chin et al., 2024). In a study with EFL learners, Alsaedi (2024) found that ChatGPT enhanced creativity by providing stylistic variation and idea generation, which helped maintain learner engagement throughout writing tasks. Luo and colleagues (2024) describe ChatGPT as offering personalized learning support tailored to students' language levels, needs, and preferences, particularly through adaptable educational content. Students in Levine and colleagues' (2025) classroom study expressed greater focus and enthusiasm when using ChatGPT to generate and refine their drafts, noting that AI support made writing more enjoyable and exploratory.

ChatGPT has been shown to support writing confidence (Alsaedi, 2024; Ghafouri et al., 2024), and some learners describe its feedback as non-evaluative, contributing to a sense of emotional safety during revision (Ghafouri et al., 2024). Students have self-reported increased confidence and reduced anxiety when working with ChatGPT, (Picton & Clark (2024). Wang (2024) reported that students described writing with ChatGPT as "less anxious," "relieving," and "accomplishment-oriented" when the feedback process was experienced as reducing evaluative pressure (p. 12). The ability of ChatGPT to adjust the level of language based on age or grade level facilitates the appropriate level of feedback, meaning even young children report feeling supported. According to work done by Smirnova

and colleagues (2025), “GPT-4o can successfully reduce text complexity on lexical, syntactic, and discourse levels,” for children, but they caution that “further fine-tuning with focus on syntax is needed” before it reaches human levels (Smirnova et al., 2025, p.1). Furthermore, while supportive, Steiss and colleagues (2024) found that the main benefits of ChatGPT feedback is in speed, not necessary quality or depth of thinking (Steiss et al., 2024).

Observations from classroom and EFL studies suggest that affective factors—such as confidence, anxiety reduction, and emotional safety—can contribute to students’ willingness to sustain writing effort (Alsaedi, 2024; Ghafouri et al., 2024; Levine et al., 2025; Mugableh, 2024). According to Ghafouri and colleagues (2024), iterative revision using ChatGPT encouraged students to reflect more actively on their drafts, contributing to greater writing persistence and self-regulatory behaviour. However, several researchers caution that these benefits may depend on how students engage with AI feedback (Alsaedi, 2024; Levine et al., 2025). In classrooms where, students adopted ChatGPT suggestions verbatim, (e.g., Levine et al., 2025; Tate et al., 2023), evidence suggests that such overreliance may undermine metacognitive development and weaken writing identity (Ghafouri et al., 2024; Levine et al., 2025). These findings underscore the importance of pairing AI support with teacher guidance that prompts students to reflect on their choices, rephrase ideas, and retain ownership over their revisions (Ghafouri et al., 2024; Levine et al., 2025). In the case of young children, the need for scaffolding is especially important. Because their executive and metacognitive systems are still developing, they are less likely to critically evaluate AI-generated suggestions and more likely to accept them without question. Research on early writing highlights that teacher guidance and age-appropriate prompting are crucial for

ensuring that AI use strengthens rather than bypasses developing cognitive skills (Luo et al., 2024; Ruffini et al., 2024).

Developing AI Literacy—Preparing Writers for AI-Integrated Classrooms

Given the complex ways students interact with AI, it becomes essential to embed AI literacy into writing instruction from an early stage something most teachers have not yet been taught to do. AI literacy is an essential aspect of effectively incorporating tools like ChatGPT and other AI writing assistants into education (Su & Yang, 2023; Tseng & Warschauer, 2023). Defined as “the ability to understand, utilize, and critically evaluate AI technologies and their societal impacts” (Su & Yang, 2023, p.356), AI literacy is crucial for students to engage responsibly with AI tools, and increasingly recognized as important for educators as well (Su & Yang, 2023; Su et al., 2023; Tate et al., 2023), a skill which can only be learned if teachers can model it, meaning teaching AI literacy is a cornerstone of proper AI use (Ghafouri et al., 2024; Levine et al., 2025; Wang & Fan, 2025). Tseng and Warschauer (2023) highlight that students lacking experience with these technologies risk falling behind in a workforce that increasingly values AI skills. To address this, they propose a pedagogical framework that includes understanding, prompting, corroborating, and critically incorporating AI-generated feedback—preparing learners to evaluate the capabilities and limitations of AI tools (Tseng & Warschauer, 2023). This strategy aims to equip students for a digital future, ensuring they can navigate AI technologies proficiently, safely, and ethically (Su & Yang, 2023; Tseng & Warschauer, 2023).

Building on this, Wang (2024) emphasizes that instruction should also support students in evaluating whether AI-generated responses align with tone, audience, and rhetorical purpose which once again returns to the ability to know what the writing elements are before they can be applied. This presupposes knowledge of writing elements such as

tone, audience, and rhetorical purpose in order to compare ChatGPT generated vs. human generated responses, which young children may not yet have. Su and Yang (2023) similarly stress that AI literacy must include ethical reflection and responsible use, identifying fairness and bias as core ethical considerations when integrating generative AI into educational contexts. Indeed, one of the largest criticisms of ChatGPT is that it produces hallucinations (Alkaissi & McFarlane, 2023; Levine et al., 2025), promotes bias due to data sets fed by the Western world (Luo et al., 2024) and may not reflect the majority of the world's reality given limited data input (Luo et al., 2024; Su & Yang, 2023). Bias occurs when generative models reproduce stereotypes, skewed perspectives, or omit key viewpoints, a very advanced cognitive skill still under construction in young children. Su and Yang, (2023) note that, because AI systems learn from human-generated datasets, they can reproduce biases present in those datasets, which may result in unfair treatment of certain student groups. To address this, Su and Yang (2023) recommend that policy and practice guidelines ensure data are "protected and used responsibly and ethically" (p. 9) and that educators "consider the ethical implications… fairness, bias, and accountability" (p. 9) when implementing AI in classrooms.

Another key limitation discussed in the literature is hallucination, which occurs when the model produces plausible but false information that may mislead learners (Su & Yang, 2023,). Alkaissi and McFarlane (2023) define AI hallucination as the generation of seemingly realistic yet factually incorrect or fabricated content, and their evaluation of ChatGPT's outputs in scientific contexts revealed entirely fictitious references and fabricated links between concepts that have no documented research basis. They caution that, while ChatGPT can produce linguistically convincing text, such inaccuracies pose significant risks to academic integrity and factual reliability. While most examples come from scientific writing

(Alkaissi & McFarlane, 2023) hallucinations have been reported at all levels, grades, ages, and in all genres of writing (e.g., Milakis et al., 2025).These limitations are particularly relevant for developing writers, who may lack the evaluative skills or domain knowledge to detect them.

Instructors are encouraged to foster reflection and rhetorical decision-making, especially during revision, by having students compare their own drafts with AI-generated revisions – a process shown to "provoke reflection on differences" between original and AI-written text and to encourage deeper critical thinking about content and style (Tseng & Levine et al., 2025; Warschauer, 2023). In classroom studies, Levine and colleagues (2025) found that students became more strategic when asked to explain their prompt choices and compare AI-generated responses to their original drafts. As research on teaching young children to correctly prompt ChatGPT are rare, the little evidence that exists (e.g., Lindrup et al., 2025) suggests that while the nature cognitive skill of comparing and contrasting work may be intuitive, learning to do so with specific elements of writing depends on the explicit instruction of the teacher (Leung, 2024).

Studies emphasize that teacher preparedness plays a central role in AI-supported writing instruction, with structured training and high teacher confidence leading to stronger writing outcomes (Campbell, 2023; Ghafouri et al., 2024). Educators who integrated ChatGPT within well-designed, scaffolded instruction helped students develop both writing and digital literacy (Ghafouri et al., 2024). Poorly guided AI use—particularly in classrooms where teachers lacked digital readiness—was associated with student confusion, overreliance, and inconsistent alignment with instructional goals (Ghafouri et al., 2024; Luo et al., 2024). These findings highlight the importance of modelling, scaffolding, and

contextualizing AI use in instructions (Campbell, 2023; Ghafouri et al., 2024; Kershen & Johnson 2025; Luo et al., 2024).

Gaps in student readiness are also reported. Alsaedi (2024) found that learners without explicit training tended to misapply ChatGPT outputs and struggled to differentiate between their own ideas and AI suggestions. Tate and colleagues (2023) extend this concern to equity, arguing that digitally fluent students gain more from AI use unless marginalized learners receive targeted instruction. Similar concerns about a widening digital divide have been raised by others advocating policy responses to ensure equal AI access (Luo et al., 2024). They highlight the need to teach citation practices, authorship boundaries, and awareness of tool limitations as part of ethical AI literacy (Tate et al., 2023).

The need for early and sustained AI literacy instruction has been emphasized by researchers who advocate integrating ethical training from early stages of exposure (Su & Yang, 2023). Others warn that learners—particularly younger or less experienced ones—may adopt AI-generated content uncritically without explicit ethical guidance, highlighting the importance of digital literacy as a safeguard (Krügel et al., 2023). Krügel and colleagues (2023) advocate digital ethics instruction that helps students recognize how AI tools may influence their moral reasoning, particularly among younger or inexperienced users. Su and Yang (2023) argue that AI literacy should be taught proactively—before passive usage habits form—and embedded in institutional digital strategy.

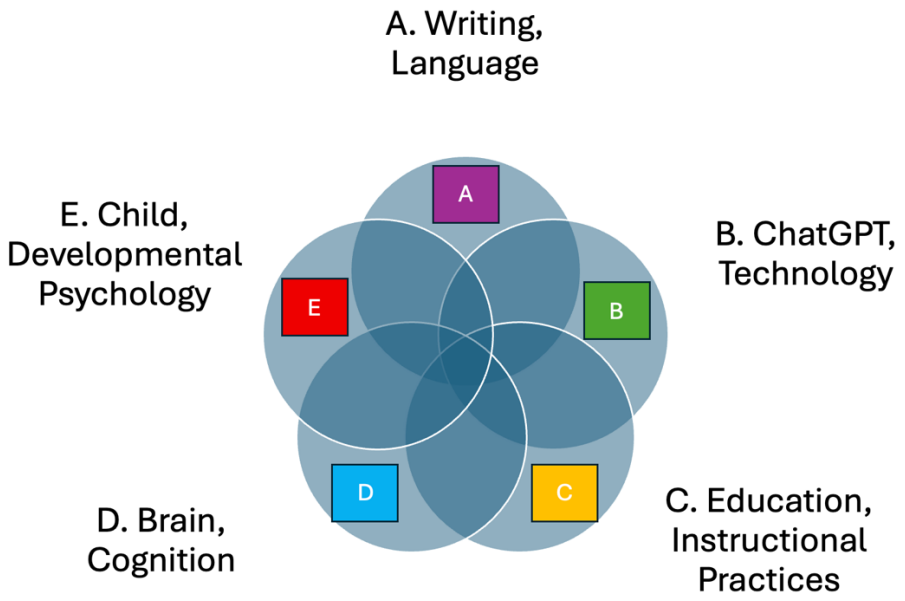
While ChatGPT offers tools for structuring and enhancing writing, this section shows that its value lies in how it is integrated. Supported use can encourage motivation, confidence, and sustained revision, while unsupervised use may reduce reflection and voice. Embedding AI literacy and maintaining instructional oversight are critical to ensuring

ChatGPT functions as a learning ally rather than a shortcut. It is clear, however, that teacher AI literacy plays a large role in determining if education systems can improve.

Methodology

The literature review was conducted in two phases to ensure depth and accuracy. In the first phase, research for this study was conducted through the Harvard On-Line Library Information System (HOLLIS) and Google Scholar. The search was limited to publications written in English accessible through reputable scientific databases, including Academic Search Premier, PsycINFO, PubMed, JSTOR, Web of Science, and ProQuest. Based on the research question, a Cartesian of five sets of search terms were used to conduct the search: (a) **language and writing** (literacy studies); (b) **technology** (ChatGPT, instructional technology); (c) **education** (instructional practices, writing best practices); (d) **cognitive neuroscience,** and (e) **developmental psychology** (Figure 3 and Table 4).

Figure 3. Fields contributing towards an answer to the research question



NOTE: This figure represents five contributing fields that published research relevant to the research question and emphasizes that most literature was found at the intersection of two or more fields as no direct evidence exists for an answer to the research question.

The initial search resulted in just over 150 theoretical papers, meta-analyses, peer-reviewed journal articles, conference proceedings, theses, books, and book chapters. Table 3 offers some examples of keyword searches from the three sub-topics of the literature review. We then applied a transdisciplinary approach to the literature by crossing keywords in a matrix design to ensure greater coverage of the literature. A list of example searches by sub-groups can be found in Table 4.

Table 3 Search terms used in research with split per sub-topic, information on filters used as well as information if results were Analyzed in study or fully excluded.

Topic 1: What specific **cognitive skills** do **young children** develop and employ during the **writing process**?		
Search terms	**Filters**	**Analyzed in study/ Fully excluded**
"neural correlates" AND "outlining" AND "writing"	N/A	Fully excluded (based on S1)
“writing" AND "cognitive development" and "children"	since 2020	Fully excluded (based on S2)
"theory of mind" and "writing" and ("children" or "primary school")	N/A	Analyzed in study
"literacy" AND "cognitive development" and "writing"	N/A	Analyzed in study
"literacy" AND "cognitive development" and "children"	N/A	Analyzed in study
"cognitive development" and "primary school" and "writing" and "neuro"	N/A	Analyzed in study
"planning" AND "outlining" AND "writing" AND "children"	since 2020	Analyzed in study
"writing" AND "outlining" AND "cognitive development" AND "children"	since 2020	Analyzed in study
"writing" AND "cognitive" AND "primary school"	since 2020	Analyzed in study
"writing to learn" AND "cognition"	N/A	Analyzed in study
"writing process" AND "Cognitive" and "primary school" and "neural"	N/A	Analyzed in study
Topic 2: What impact does **ChatGPT** have **on cognitive development** among **developing writers**?		
Search terms	**Filters**	**Analyzed in study/ Fully excluded**
"ChatGPT" AND "cognitive development" AND "primary school children"	N/A	Fully excluded (based on S1)
("ChatGPT" OR "GPT") AND "NEURAL NETWORK*" AND "HUMAN"	N/A	Fully excluded (based on S1)
"ChatGPT" AND "cognitive development" AND "young children"	N/A	Fully excluded (based on S2)
"ChatGPT" AND "primary school" AND "cognition"	N/A	Analyzed in study
“ChatGPT” AND "cognitive development" AND "children"	N/A	Analyzed in study
("ChatGPT" OR "GPT") AND "COGNITIVE" AND "EXPERIMENTAL"	N/A	Analyzed in study
("ChatGPT" OR "GPT") AND "CRITICAL THINKING" AND "PRIMARY SCHOOL"	N/A	Analyzed in study
Topic 3: What is the impact of **ChatGPT** on the **writing process** of **developing writers**?		
Search terms	**Filters**	**Analyzed in study/ Fully excluded**
"ChatGPT" AND "outline" AND "writing"	N/A	Fully excluded (based on S1)
"ChatGPT" AND "writing" AND "primary school"	N/A	Analyzed in study
"ChatGPT" AND "outline" AND "writing" AND "primary school"	N/A	Analyzed in study

("ChatGPT" or "GPT" or "ai" or "LLM") and "writing process"	N/A	Analyzed in study
"ChatGPT" AND "writing" AND "children"	N/A	Analyzed in study
("ChatGPT" OR "GPT") AND "cognitive" AND "planning" AND "primary school"	N/A	Analyzed in study
"ChatGPT impact" AND "writing" AND "young learners"	N/A	Analyzed in study
"AI-assisted learning" AND "primary education" AND "writing"	N/A	Analyzed in study

1

2 **Table 4 Keyword samples by categories and number of related articles used in review**

Category	Example Keyword combinations (not exhaustive)	Number of Articles included in Review after filtering for timeframe
A Writing, Language	Writing, literacy, language, emergent writing, metalinguistic awareness, pre-literacy, reading, letter formation, drawing to write, evidence-based writing,	1
B ChatGPT, Technology	ChatGPT, chatbot, new technology, Khanmigo, human-computer interface, prompts, OpenAI, educational technology,	7
C Education, instructional practice	Education, instruction, instructional practice, best practice, school policy, school, classroom, teacher, student, classroom activity, strategy, intervention, early childhood education	1
D Brain, Cognition	Memory, attention, executive functions working memory, long-term memory, semantic memory, autobiographical memory, inhibitory control, self-regulation, theory of mind, metacognition, neural correlates, cognitive offloading, cognitive load	2
E Child, Developmental Psychology	Child, preschool, kindergarten, primary school early development, developmental stages, early years, ages 5-11	1
AB Language-Technology	("ChatGPT" or "GPT" or "AI" or "LLM") AND "outline" AND "writing"; ("ChatGPT" or "GPT" or "AI" or "LLM") AND "writing process";	8
AC Language-Education	“writing instruction” AND “best practice” AND “school”; “evidence-based” AND “writing instruction”	15
AD Language-Cognition	"neural correlates" AND "outlining" AND "writing"; "writing to learn" AND "cognition";	25
AE Language-Development	"literacy" AND "cognitive development" and "writing"; "literacy" AND "cognitive development" and "children"; "planning" AND "outlining" AND "writing" AND "children"; "writing" AND "outlining" AND "cognitive development" AND "children"	5
BC	("ChatGPT" or "GPT" or "AI" or "LLM") AND “classroom activity”; “OpenAI” AND “school”; “ChatGPT” AND	9

Category	Example Keyword combinations (not exhaustive)	Number of Articles included in Review after filtering for timeframe
Technology-Education	“prompt” AND “teacher”; “ChatGPT” AND “early childhood education”; “Khanmigo” AND “primary school literacy”;	
BD Technology-Cognition	("ChatGPT" or "GPT" or "AI" or "LLM") AND "NEURAL NETWORK*" AND "HUMAN"; ("chatGPT" OR "GPT") AND "COGNITIVE" AND "EXPERIMENTAL";	4
BE Technology-Development	("ChatGPT" or "GPT" or "AI" or "LLM") AND “early years” AND “development”; “educational technology” AND “child development”; “human-computer interface” AND “children”; “OpenAI” AND “preschool”	2
CD Education-Cognition	“classroom” AND “self-regulation”; “teaching strategies” AND “memory”; “early childhood education” AND inhibitory control”; “school” AND “executive functions”; “teacher-student relations” AND “self-regulation”	0 (too broad, 47,000+ results between 2021-2025; added third element, see ACD; BCD; CDE
CE Education-Development	“preschool” AND “early childhood” AND “development”; “teaching” AND “young children”; “instructional practice” AND “childhood development”	0 0 (too broad, 137,000+ results between 2021-2025; added third element, see ACE, BCE, DCE
DE Cognition--Development	“young children” AND “memory”; “kindergarten” AND attention”; “early development” AND “metacognition”; “children” AND “self-regulation	7
ABC Language-Technology-Education	“writing” AND “ChatGPT” AND “education”; “literacy” AND “ChaptGPT” AND “school”; “writing instruction” AND “ChatGPT” AND “classroom activity	13
ABD Language-Technology-Cognition	“writing instruction” AND “ChatGPT” AND “metacognition”; “writing” AND “ChatGPT” AND “theory of mind”; “literacy” AND “ChatGPT” AND “attention”	1
ABE Language-Technology-Development	"chatgpt" AND "writing" AND "primary school"; "chatgpt" AND "outline" AND "writing" AND "primary school"; "ChatGPT" AND "writing" AND "children"; "ChatGPT impact" AND "writing" AND "young learners"	7
ACD Language-Education-Cognition	“writing” AND classroom” AND “executive functions”; “literacy instruction” AND “student” AND “activity” AND “self-regulation”; “writing” AND “school” AND “metalinguistic*”	8
ACE Language-Education-Development	"writing" AND "cognitive" AND "primary school"; “language development” AND “classroom activity” AND “early childhood development”	19

Category	Example Keyword combinations (not exhaustive)	Number of Articles included in Review after filtering for timeframe
ADE Language-Cognition-Development	“writing" AND "cognitive development" and "children"; "theory of mind" and "writing" and ("children" or "primary school"); "writing process" AND "Cognitive" and "primary school" and "neural";	38
BCE Technology-Education-Development	"ChatGPT" AND "cognitive development" AND "primary school children"; "ChatGPT" AND "cognitive development" AND "young children"; "AI-assisted learning" AND "primary education" AND "writing"	2
BDE Technology-Cognition-Development	“chatgpt” AND "cognitive development" AND "children"; ("chatGPT" OR "GPT") AND "CRITICAL THINKING" AND "PRIMARY SCHOOL"; ("chatGPT" OR "GPT") AND "cognitive" AND "planning" AND "primary school"	2 (add Abrar, 2025) (add Nikolopoulou, 2024)
CDE Education-Cognition-Development	“classroom” AND “self-regulation” AND “early childhood development; “teaching strategies” AND “memory” AND “children”; “early childhood education” AND inhibitory control” AND “developmentally appropriate behavior”	5
ABCD Language-Technology-Education-Cognition	“language” AND “technology” AND “education” AND “cognition”; “writing” AND “ChatGPT” AND “classroom” AND “attention”; “writing instruction” AND “educational technology” AND “students” AND “self-regulation	0 (too broad, word choice refined for precision)
ABCE Language-Technology-Education-Development	“writing” AND “AI” AND “school policy” AND “early childhood”; “writing instruction” AND “ChaptGPT” AND “classroom” AND “child development”	0 (too broad, word choice refined for precision)
ABDE Language-Technology-Cognition-Development	“literacy” AND “AI” AND “executive functions” AND “early development”; “writing” AND “AI”AND “theory of mind” AND “childhood”	1
ACDE Language-Education-Cognition-Development	"cognitive development" and "primary school" and "writing" and "neuro"; “writing instruction” AND “primary school classroom” AND “metacognition” AND “early development”	2
BCDE Technology-Education-Cognition-Development	“Generative AI” AND “education” AND “cognitive offloading” AND “youth”; “ChatGPT” AND “teachers” AND “self-regulation” AND “kindergarten”	2

The first phase search was conducted based on three sub-topics of the Literature Review, which involved using a matrix of keywords and their variants (Table 4.) Boolean operators “AND,” “OR” and “NOT” were used to link variants of keywords in each of the five categories as explained in Tables 3 and 4. This first review of the literature focused on the

influence of ChatGPT on the cognitive development of developing writers, particularly concerning their thought processes during writing. The selected research studies primarily involved children in early childhood, kindergarten and the primary grades. However, due to the limited number of studies available for the age group of interest, some studies conducted on student populations were also considered if their conclusions could support the analysis of AI's impact on writing. The selected research studies considered ChatGPT as an educational tool and studies in which it was used in experimental research was given priority. As the first step of selection (S1) titles and abstracts of articles were reviewed in detail. Articles that appeared to be relevant to the research question were examined in more detail by scanning the abstract, conclusion and methodology sections if needed (S2). This initial search yielded just over 150 high quality articles. To refine the search and use the most up-to-date sources possible, papers written after 2021 were given priority. Snowballing was used with the final reference lists to identify further papers that were relevant and significant to the research question. Papers related to policy recommendations, government reports, and opinion papers were read but not included in the analysis.

To ensure the inclusion of the most current developments in the field, there was a second phase of research conducted during 2025 to ensure the inclusion of the most current developments in the field. Aside from HOLLIS's databases, an additional search was conducted using an additional tool, Elicit, an AI-based research assistant that identifies and synthesizes relevant academic literature from the Semantic Scholar corpus (Elicit, n.d.). A full summary of the tool's screening process and paper suggestions is available in the report used for this search (see Elicit Report, 2025). Additional research papers were added through this process selected, either directly from Elicit's recommendations or from the reference lists of those papers. Newer papers brought the total number of papers to 216.

While no country-specific filters were included, most research papers analyzed focused on the U.S. population. No empirical research was found on the topic of ChatGPT usage and its implications for cognitive development for the developing writers, the primary research question of this paper, which meant reliance on papers in the sub-topics of the question. As a final step, both the main research question and the sub-topics were input into ChatGPT and perplexity.ai, both of which served as AI-based platforms for generating suggestions of research papers that could be explored to address them. No additional sources were added based on this step. At no other time was ChatGPT used in this research process.

Analysis

The synthesis of the literature reveals that integrating ChatGPT into writing education is not merely a technological addition; it has significant implications for cognitive development and educational practices that cannot be understood in isolation. This necessitated a transdisciplinary approach to the research which integrated language, technology, education, cognitive neuroscience, and developmental psychology to fully understand and address the potential impacts. The sum of the literature pointed to two expected and three unexpected findings (Table 5).

Expected and Unexpected Findings

It was anticipated that writing plays a crucial role in the development of cognitive functions in children, engaging multiple neural pathways and enhancing skills essential for academic success and societal engagement (McCutchen, 2006; Ruffini et al., 2024). The process of writing supports critical thinking, problem-solving, and decision-making abilities.

An unexpected finding is the substantial gap in empirical studies specifically examining the impact of ChatGPT on the cognitive development of young writers aged 5 to 11 years. The literature primarily focuses on the practical applications of ChatGPT rather than its cognitive implications for developing writers (Luo et al., 2024). This deficiency highlights an urgent need for targeted investigations to fully understand the potential impacts. At its core, the analysis reveals that ChatGPT is not inherently beneficial or harmful, its impact is shaped by the pedagogical context in which it is used. The sum of the literature suggests that the effects of ChatGPT on young writers are shaped less by the tool itself than by the developmental, instructional, and emotional contexts into which it is introduced.

Table 5. Summary of Expected and Unexpected Findings in the Literature

Unexpected:	The cognitive necessity of process over product due to the hierarchy of neural correlates that underpin writing, and the instructional conditions that support it.
Unexpected:	Writing as a space for emotional growth and identity construction—and what AI may displace.
Expected:	How instruction, adult scaffolding, and AI literacy must interact to support development.
Expected:	The paradox of ChatGPT as both a potential developmental scaffold and a shortcut.
Unexpected:	Unexplored impacts on distinct cognitive functions and the risks of broad offloading claims.

Writing Development Requires Process, Not Only the Product

ChatGPT produces good writing products (Steiss et al., 2024), and educational evaluation tends to prize those products. Underpinning those products, however, is the invisible thinking behind the writing (Tokuhama-Espinosa et al., 2024), which has become

the focus of the current debate in this paper. Cognitive, educational, and psychological literature converge on the importance of writing as staged developmental processes. There is evidence for a clear hierarchy of neural circuits underpinning writing abilities (Tokuhama-Espinosa, et al., 2024), which point to the vulnerability of these skills considering ChatGPT's influence on nascent networks in the brain, especially related to executive functions. When writing processes emphasizes planning, drafting, and revising—rather than just the final product—students engage cognitive skill development, including executive functions such as working memory, attention, and self-regulation (McCutchen, 2006; Ruffini et al., 2024). This emphasis on thinking processes is developmentally consequential, given evidence that early writing practice positioned as repeated, effortful practice predicts growth in children's self-regulation over time (Puranik & Li, 2022). Educators who prioritize process-oriented writing instruction help students develop cognitive skills more fully (Latham, 2002). This approach encourages students to reflect on their thinking, engage deeply with writing, and develop both higher-order cognition and resilience when working through difficulty (Campbell, 2023). The sum of the literature suggests that while ChatGPT can be used to support the natural learning trajectory of writing skills, normally it is used to produce a product, not to stimulate the thinking processes. That is, the emphasis on its classroom use has sided with more product-oriented goals to expedite writing with just a handful of tools focused on explicitly guiding thinking processes (e.g., Khanmigo [Khan, 2024]). Embracing challenging tasks within this approach reflects the principles of a growth mindset (Dweck, 2006), in which effort, persistence, and reflection drive development. A process-based instructional approach is not only pedagogically sound but cognitively essential for developing writers (Graham & Sandmel, 2011; Graham et al., 2012).

The sum of the evidence seems to suggest that, as writing and thinking are interdependent and inter-reliant, valuing the process and hierarchy of skills that cognitively support writing should be valued as much as the product itself. This means ChatGPT can both help and hurt developing writers; the cognitive development of young writers appears to depend more on the focus of writing instruction and how teachers choose to use than on the tools they use. The literature consistently shows that instructional design—task structure, feedback strategies, assessment practices, and sustained support—has a deeper and more lasting impact on writing development than any single technological intervention (Campbell, 2023; Latham, 2002). The body of evidence suggests that even without the presence of AI, a shift toward process-oriented writing instruction is needed to activate the full cognitive potential of young writers (Graham & Sandmel, 2011; Graham et al., 2012; Tokuhama-Espinosa et al., 2024).

This shift becomes even more relevant considering the growing use of AI writing assistants like ChatGPT. While such tools can support feedback, language clarity, and revision, they are by default oriented toward output and speed (Marchetti et al., 2025; Wang, 2024). Without thoughtful integration, they may encourage surface-level editing and bypass the cognitive demands of the writing process. However, given their increasing presence in classrooms and beyond, it may be more constructive to treat these tools as catalysts for reinforcing stage-based writing instruction. When educators embed ChatGPT into a process-oriented framework—with clear goals, reflection, and feedback at each stage—it becomes possible to use AI not to replace cognitive effort, but to scaffold and deepen it. Teacher knowledge of the understanding of the neural hierarchy underpinning the trajectory seems vital to the ability to select when ChatGPT use is helpful and when it is harmful. Educational training can guide teachers' appreciation for when and how to best use ChatGPT.

Writing as Emotional and Identity Formation: What AI Cannot Replace

While writing is widely recognized as a cognitively demanding process, it also plays a critical role in social-emotional development and identity formation. Writing supports children in processing emotions, communicating feelings, reflecting on experiences, and developing empathy through storytelling (Guimaraes, 2023), making it a developmental tool that extends far beyond language mechanics. These functions, though well-supported in literature from psychology, education, and developmental linguistics, are rarely addressed in discussions of AI integration in writing instruction.

AI writing tools like ChatGPT, which are optimized for fluency and correctness, do not account for the expressive, reflective, and relational dimensions of writing. Writing is one of the primary ways children externalize their inner thoughts (Olson, 2002), shaping both how they see the world and how they see themselves within it. When children engage in storytelling or narrative construction, they are not simply practicing composition; they are participating in the development of emotional insight and authorial identity. These outcomes emerge through self-expression, as students articulate values, explore perspectives, and gradually construct a coherent sense of self. When AI is used without support, the struggle to communicate lived experience, a key part of this process, may be diminished. Wittgenstein states that language, and most importantly vocabulary development in the early years, fortifies self-understanding (Stern, 1995). A core idea in social-emotional learning is *name it to tame it* (Siegel, 2012) meaning that being able to communicate with words facilitates the expression of emotional experiences.

From a transdisciplinary perspective, this raises concerns about how AI use may obscure the developmental functions of writing that are not easily quantified. While feedback on grammar or coherence may improve surface-level quality, it cannot substitute for the

internal processes by which students construct self-understanding and social meaning. This implies that writing done in collaboration—with peers, caregivers, or teachers—serves not just cognitive goals but relational and emotional ones as well (Guimaraes, 2023). However, when ChatGPT is used as a substitute for these dialogic experiences, it may bypass the socially co-constructed nature of meaning-making or at the least, create false expectations or normal human interaction. Over time, repeated reliance on external generation may reduce opportunities for students to build voice, empathy, and reflective awareness—skills that writing is uniquely positioned to develop, as Guimaraes points out (2023).

These risks do not suggest that AI should be excluded from writing instruction, but rather that its use must be framed with an understanding of what writing also does: it supports personal growth, emotional regulation, value clarification, identity construction, and the motivational benefits that stem from ownership. Without intentional guidance, students may come to see writing as a task of correction and polish, rather than a space for expression and self-authorship.

Designing for Cognitive Growth in the Age of AI: Instruction, Adults, and AI Literacy

Following the cognitive (e.g., Fei et al., 2024), emotional (e.g., Dong et al., 2024), and identity-building roles (e.g., Ventä-Olkkonen et al., 2024) of writing outlined previously, it becomes clear that no single factor determines how ChatGPT will impact learning. Rather, three elements—instructional design, adult guidance, and AI literacy—must function as a system to preserve the developmental goals of writing education. As a new tool, AI literacy – or learning the language of AI – is key but research suggests young children are more likely to show AI literacy if their teachers have it (Yim & Wegerif, 2024).

Instructional design, or the purposeful choice of learning activities and resources, , structure the writing process in ways that activate executive function and metacognitive reflection (McCutchen, 2006; Ruffini et al., 2024). Adult guidance adds dialogic support, helping students interpret, question, and reflect (Kervin et al., 2020). But even these elements may fall short in the presence of generative AI, which can offer a more soothing, upbeat, encouraging tone than many teachers unless students develop internal frameworks for how to use the tool which is the essence of AI literacy (Tseng & Warschauer, 2023).

AI literacy is not synonymous with technical fluency. Rather than teaching students what ChatGPT can do, it involves helping them understand when, why, and how to use the tool in ways that preserve agency and cognitive effort. The literature acknowledges that children are unlikely to self-regulate their tool use without explicit guidance (Ghafouri et al., 2024; Levine et al., 2025; Luo et al., 2024; Su & Yang, 2022). This makes AI literacy a developmental construct – one that blends metacognition, critical evaluation, and strategic tool use, including the ability to recognize and respond to limitations in AI-generated content.

Two of the most critical limitations of AI output, bias and hallucinations, carry particular significance for young writers (Dwivedi et al., 2023; Su & Yang, 2023) who need guidance from adults to avoid their pitfalls (Ghafouri et al., 2024; Levine et al., 2025; Luo, 2024; Su & Yang, 2022). Marchetti et al. (2025) caution that the apparent success of large language models in cognitive tasks often reflects their ability to replicate patterns from training data rather than any internal comprehension, creating an illusion of understanding. If students cannot recognize these patterns of typical or biased information or invented hallucinations, they may adopt them without question. For developing writers, this is not simply an ethical concern but a cognitive one, as undetected bias or factual inaccuracy shapes what they consider valid knowledge and how they frame their ideas. Over time, such

unchecked outputs can unintentionally shape their worldview. Encouraging students to identify, question, and cross-check AI responses—whether for potential bias or factual accuracy—keeps them active in the meaning-making process and prevents AI from becoming an unquestioned authority. Embedding these checks into writing instruction transforms them from reactive corrections into deliberate cognitive practices, strengthening both critical thinking and metacognitive control.

For example, students prompted to evaluate multiple outputs or identify weaknesses in suggestions begin to internalize these critiques; the habitual rehearsal of comparing and contrasting writing styles can help students find their own voice. Those who track how AI revisions align with their intentions develop metacognitive control. These capacities do not emerge automatically. They must be intentionally cultivated, often in collaboration with adults, and eventually reinforced through reflective habits. The rehearsal necessary to reinforce speedy responses to thinking challenges can be cut short by ChatGPT use or can be enhanced when cognitive substrates are reinforced through its use.

AI literacy becomes the synchronizing layer because it actively links instructional design and adult guidance to the presence of AI, ensuring they work together rather than operating in parallel. It is not simply tool competence; it is a developmental skillset, one that enables students to preserve authorship, ownership, and intentionality in tool use. Adults can model it. But students must practice it until they learn to use tools to think with, not simply write faster. Without AI literacy, even well-designed instruction risks being overridden by the speed and fluency of automated output.

The Paradox of ChatGPT: Support vs Hindrance

Understanding how ChatGPT influences young writers requires a stage-sensitive analysis of the writing process. As outlined in Table 2 (see Literature Review), writing

unfolds through multiple phases—each involving distinct cognitive demands and developmental functions (Latham, 2002; McCutchen, 2006; Ruffini et al., 2024; Tokuhama-Espinosa et al. 2024). By examining ChatGPT's role at each stage, this section synthesizes how the tool may support or hinder young writers' growth, depending on how it is implemented.

Rather than evaluating AI use in general, the following table presents a side-by-side analysis of how ChatGPT interacts with each writing stage based on evidence from the literature. For each phase—prewriting, drafting, knowledge-building, reviewing and revising, editing, and presenting—the table identifies possible forms of support and potential risks. These are grounded in findings from the literature review, including references to executive functions (e.g., inhibition, sequencing), metacognition, emotional engagement, and learner agency. For ease of rendering, each reference is numbered and explained in the Note.

ChatGPT's Potential Support and Hindrance Across Writing Stages

Table 6 summarizes the benefits and drawbacks or support vs. hinderances that ChatGPT can have on emergent writers. This table summarizes the over 200 articles and their insights to identify 25 pros and cons to ChatGPT use.

Table 6 ChatGPT Support vs. Hinderance Roles

Writing stages	How ChatGPT Can Support		How ChatGPT Can Hinder	
	What ChatGPT supports	**How it can work based on literature**	**What ChatGPT may hinder**	**How it is based on literature**
Prewriting	Can provide scaffolding for idea generation and early topic development.	By offering structured prompts and examples and outlines that mirror peer or tutor support (1).	May bypass executive function during planning and brainstorming.	When students use ChatGPT too early, they may skip idea generation (2), which disrupts and limits the practice of cognitive skills such as inhibition, sequencing, and self-initiation (3).
	Can aid early planning by suggesting structure.	By offloading some organization tasks so students can focus on content and coherence (4).	May reduce metacognitive ownership of ideas.	Students may accept AI-generated suggestions without evaluating their purpose or accuracy (5), limiting reflective control over writing (6).
	Can support multilingual or emerging writers articulate initial ideas more fluently.	By providing sentence starters and vocabulary that ease language formulation (7).	May inhibit divergent or creative thinking.	Children may treat ChatGPT's responses as "correct," limiting exploration of alternative ideas (8) or personal voice (9).

Writing stages	How ChatGPT Can Support		How ChatGPT Can Hinder	
	What ChatGPT supports	**How it can work based on literature**	**What ChatGPT may hinder**	**How it is based on literature**
	Can be used with teacher or parent guidance to structure prewriting steps.	When integrated into guided classroom dialogue or home support, allowing children to retain agency (10).	May reduce personal voice and narrative ownership.	ChatGPT overuse at early stages may lead to generic outputs that don't reflect children's real experiences (11) or diminish personal voice and narrative ownership (12).
Knowledge building	Can support content knowledge expansion.	By providing background information, definitions, or vocabulary tailored to topic focus (13).	May discourage independent knowledge construction.	When overused as a source of information, it may reduce motivation to explore content independently (14) and encourage passive consumption of information (15).
	Can assist multilingual learners in vocabulary development.	By suggesting synonyms, contextual phrasing, or simple definitions that ease language gaps (16).	May weaken long-term retention of knowledge.	Cognitive offloading reduces memory consolidation (17) and internalization of information (18).

Writing stages	How ChatGPT Can Support		How ChatGPT Can Hinder	
	What ChatGPT supports	**How it can work based on literature**	**What ChatGPT may hinder**	**How it is based on literature**
	Can guide students in organizing factual or topic-based content.	By generating outlines or structuring concept sequences aligned with schema development (19).	May bypass conceptual struggle needed for deep understanding.	When used to shortcut inquiry or problem-solving, it limits critical thinking (20) and reasoning development (21).
	Can activate prior knowledge through question prompts.	By providing examples or follow-up suggestions that connect new information to familiar concepts (22).	May reinforce superficial engagement with topics.	Over-reliance on surface-level suggestions can limit analysis (23) and reflective processing (24).
			May introduce factual inaccuracies or misleading content (hallucination).	ChatGPT can generate plausible but false information (25), which may confuse learners (26) or misinform early content knowledge (27) if not carefully checked.

Writing stages	How ChatGPT Can Support		How ChatGPT Can Hinder	
	What ChatGPT supports	**How it can work based on literature**	**What ChatGPT may hinder**	**How it is based on literature**
Drafting	Can assist sentence construction and word choice development.	By providing contextual phrasing, grammar support, and vocabulary feedback for sentence development (28).	May bypass idea-to-text translation practice.	When students use AI to generate complete sentences, they skip the effortful cognitive process of converting ideas into written form (29), weakening formulation skills (30).
	Can reduce working memory load during drafting.	By handling grammar and structure mechanics, such as suggesting word order, transitions, or punctuation like a real-time writing assistant, so students can concentrate on the content, flow, and coherence of what they want to say (31).	May reduce young writer's sense of authorship and engagement.	When key story or content choices are generated by ChatGPT, children risk disengaging from the meaning-making process (32) and self-expression (33), hence may feel less connected to what they're writing (34).

Writing stages	How ChatGPT Can Support		How ChatGPT Can Hinder	
	What ChatGPT supports	**How it can work based on literature**	**What ChatGPT may hinder**	**How it is based on literature**
	Can support multilingual learners with cohesion and syntax.	By providing examples of sentence connections, transitions, and phrasing across languages that support flow (35).	May limit the development of personal voice or writing style.	AI-generated drafts can feel generic, limiting children's ability to develop a distinct writing voice or tone (36).
	Can model audience-aware writing.	By generating examples that reflect tone, formality, and structure appropriate for different readers to simulate Theory of Mind (ToM) perspective-taking (37).	May inhibit Theory of Mind development.	When students adopt AI phrasing without reflection, they miss the opportunity to think about audience needs and clarity (38).
Reviewing & Revising	Can scaffold revision planning.	By generating feedback questions like “Could this be clearer?” or “Is this your strongest argument?”, which encourages critical thinking and revision goal-setting (39).	May discourage self-monitoring or independent revision.	When students rely on AI to identify and correct issues, they may not practice scanning (40), rethinking (41), or improving (42) their own drafts.

Writing stages	How ChatGPT Can Support		How ChatGPT Can Hinder	
	What ChatGPT supports	**How it can work based on literature**	**What ChatGPT may hinder**	**How it is based on literature**
	Can support content improvement through feedback prompts.	By posing revision questions or paraphrasing suggestions that spark critical reflection and problem-solving (43).	May bypass metacognitive reflection.	If revision is reduced to AI reformulation, students might not engage with deeper questions about argument logic or message clarity (44).
	Can help detect errors and inconsistencies.	By flagging grammar, punctuation, and repeated words, helping students notice surface errors they may miss (45).	May reduce awareness of audience and intention.	Overreliance on AI phrasing can disconnect students from thinking about how their words affect others (46).
	Can promote flexible revision strategies.	By allowing students to compare different phrasings or structures, which fosters cognitive flexibility in rewriting (47).	May lead to overcorrection or overly formal writing.	ChatGPT may produce technically accurate but generic suggestions that flatten style or suppress student voice (48). Students may assume ChatGPT outputs are better, reducing their engagement (49).

Writing stages	How ChatGPT Can Support		How ChatGPT Can Hinder	
	What ChatGPT supports	**How it can work based on literature**	**What ChatGPT may hinder**	**How it is based on literature**
	Can help adjust tone when guided by adults.	When embedded in teacher-led reflection, ChatGPT suggestions can help students consider how their writing affects readers (50).		
	Can support second-language learners in revising fluency and accuracy.	When guided by teachers, ChatGPT suggestions support precise grammar use and reinforce learning of language vocabulary alternatives and structures (51).		
Editing	Can assist with grammar, spelling, and punctuation correction.	By flagging surface-level errors and prompting students to reflect on them, helping reinforce attention to language	May weaken error detection skills.	When students accept ChatGPT suggestions without reflection, they may rely on AI to notice errors instead of scanning independently (53).

Writing stages	How ChatGPT Can Support		How ChatGPT Can Hinder	
	What ChatGPT supports	**How it can work based on literature**	**What ChatGPT may hinder**	**How it is based on literature**
		conventions (52).		
	Can help students recognize patterns of common mistakes.	By identifying recurring grammar or syntax errors, ChatGPT can support language rule awareness over time (54).	May reduce practice in applying grammar rules.	If corrections are accepted automatically, students may miss opportunities to recall and apply learned language conventions (55).
	Can reduce editing-related anxiety for young or multilingual writers.	By providing low-stakes, non-judgmental feedback that encourages experimentation with self-editing (56).	May create false sense of correctness.	Students may over trust AI suggestions, overlooking subtle grammar or meaning issues, which can erode critical evaluation skills (57).
Sharing	Can support audience awareness and final clarity.	By helping students consider how their writing will be received through audience-specific prompts, modelling perspective-taking aligned with Theory of Mind (58).	May blur sense of authorship.	If students don't recognize their contribution to the final product, especially before public sharing, they may feel less pride and ownership in what they present (59).

Writing stages	How ChatGPT Can Support		How ChatGPT Can Hinder	
	What ChatGPT supports	**How it can work based on literature**	**What ChatGPT may hinder**	**How it is based on literature**
	Can boost student confidence before presenting work.	By offering neutral feedback and surface-level polishing that reduce anxiety related to public sharing (60).	May reduce confidence in authentic voice.	Over-polishing by AI for audience appeal may lead students to undervalue their original tone (61) or emotional expression (62).
	Can simulate audience feedback.	By generating questions or comments that mimic peer or reader reactions, which helps young writers revise with purpose (63).	May create reliance on external validation.	If AI feedback shapes their sense of readiness to share, students may become less motivated by their own growth or effort (64).
	Can offer sharing/publishing formats.	By suggesting ways to format or adapt writing for digital or classroom publication, which reinforces writing as communication (65).	May diminish critical thinking before presenting.	If students rely on AI for final feedback, they may skip active evaluation of how their writing will be understood or interpreted by others (66).

NOTE: Summary of 25 pros and cons of ChatGPT use with young children based on the literature.
Numbers in parentheses correspond to supporting sources as follows:
(1) Alsaedi (2024); Levine et al. (2025); Luo et al. (2024); Wang (2024); Wang & Fan (2025); Yin (2024).
(2) Campbell (2023); Levine et al. (2025).

(3) Beck & Levine (2023).
(4) Alsaedi (2024); Wang & Fan (2025); Yin (2024).
(5) Ghafouri et al. (2024); Levine et al. (2025); Marchetti et al. (2025).
(6) Beck & Levine (2023); Ghafouri et al. (2024); Levine et al. (2025); Marchetti et al. (2025).
(7) Athanassopoulos et al. (2023); Smirnova et al. (2025).
(8) Ghafouri et al. (2024); Levine et al. (2025); Marchetti et al. (2025); Wang & Fan (2025).
(9) Campbell (2023); Levine et al. (2025).
(10) Alsaedi (2024); Levine et al. (2025); Wang & Fan (2025); Yin (2024).
(11) Campbell (2023); Levine et al. (2025); Marchetti et al. (2025); Wang (2024); Wang & Fan (2025).
(12) Beck & Levine (2023); Campbell (2023); Levine et al. (2025); Olson (2002); Wang (2024).
(13) Alsaedi (2024); Beck & Levine (2023); Luo (2024); Yin (2024).
(14) Ghafouri et al. (2024); Wang (2024); Wang & Fan (2025); Yin (2024).
(15) Alsaedi (2024); Campbell (2023); Ghafouri et al. (2024); Marchetti et al. (2025).
(16) Alsaedi (2024); Beck & Levine (2023); Mugableh (2024); Wang (2024).
(17) Beck & Levine (2023); Campbell (2023).
(18) Olson (2002); Wang & Fan (2025).
(19) Alsaedi (2024); Beck & Levine (2023); Levine et al. (2025); Wang (2024); Wang & Fan (2025); Yin (2024).
(20) Alsaedi (2024); Wang & Fan (2025); Yin (2024).
(21) Beck & Levine (2023); Ghafouri et al. (2024); Marchetti et al. (2025); Olson (2002).
(22) Ghafouri et al. (2024); Levine et al. (2025); Wang (2024); Yin (2024).
(23) Alkaissi & McFarlane (2023); Kosmyna et al. (2025); Levine et al. (2025); Marchetti et al. (2025).
(24) Ghafouri et al. (2024); Levine et al. (2025).
(25) Alkaissi & McFarlane (2023); Levine et al. (2025).
(26) Marchetti et al. (2025).
(27) Alkaissi & McFarlane (2023); Tate et al. (2023).
(28) Alsaedi (2024); Beck & Levine (2023); Kim (2023); Mugableh (2024); Smirnova et al. (2025); Wang (2024).
(29) Campbell (2023); Ghafouri et al. (2024); Levine et al. (2025); Wang (2024).
(30) Beck & Levine (2023); Kosmyna et al. (2025); Levine et al. (2025).
(31) Alsaedi (2024); Kim (2023); Levine et al. (2025); Smirnova et al. (2025).
(32) Ghafouri et al. (2024); Levine et al. (2025).
(33) Campbell (2023); Wang (2024).
(34) Levine et al. (2025); Olson (2002).
(35) Alsaedi (2024); Kim (2023); Smirnova et al. (2025); Wang (2024).
(36) Campbell (2023); Levine et al. (2025); Wang (2024).
(37) Alsaedi (2024); Beck & Levine (2023); Levine et al. (2025); Yin (2024).
(38) Campbell (2023); Ghafouri et al. (2024); Kosmyna et al. (2025); Levine et al. (2025).
(39) Alsaedi (2024); Beck & Levine (2023); Ghafouri et al. (2024); Levine et al. (2025); Yin (2024).
(40) Alsaedi (2024); Levine et al. (2025).
(41) Campbell (2023); Ghafouri et al. (2024).
(42) Kosmyna et al. (2025); Marchetti et al. (2025); Tate et al. (2023).
(43) Alsaedi (2024); Beck & Levine (2023); Ghafouri et al. (2024); Levine et al. (2025); Yin (2024).
(44) Alsaedi (2024); Ghafouri et al. (2024); Kosmyna et al. (2025); Levine et al. (2025); Marchetti et al. (2025).
(45) Alsaedi (2024); Kim (2023); Levine et al. (2025); Smirnova et al. (2025).
(46) Campbell (2023); Ghafouri et al. (2024); Kosmyna et al. (2025); Levine et al. (2025).
(47) Beck & Levine (2023); Ghafouri et al. (2024); Levine et al. (2025); Yin (2024).
(48) Campbell (2023); Wang (2024).
(49) Alsaedi (2024); Levine et al. (2025); Marchetti et al. (2025).
(50) Alsaedi (2024); Beck & Levine (2023); Levine et al. (2025); Yin (2024).
(51) Alsaedi (2024); Kim (2023); Mugableh (2024); Smirnova et al. (2025); Wang (2024).

(52) Alsaedi (2024); Kim (2023); Levine et al. (2025); Luo (2024); Smirnova et al. (2025).
(53) Alsaedi (2024); Ghafouri et al. (2024); Levine et al. (2025); Luo (2024); Marchetti et al. (2025).
(54) Alsaedi (2024); Kim (2023); Levine et al. (2025); Luo (2024).
(55) Alsaedi (2024); Ghafouri et al. (2024); Levine et al. (2025).
(56) Alsaedi (2024); Ghafouri et al. (2024); Smirnova et al. (2025); Wang (2024).
(57) Alkaissi & McFarlane (2023); Kosmyna et al. (2025); Levine et al. (2025); Marchetti et al. (2025).
(58) Alsaedi (2024); Beck & Levine (2023); Levine et al. (2025); Luo (2024); Yin (2024).
(59) Campbell (2023); Levine et al. (2025); Olson (2002); Wang (2024).
(60) Ghafouri et al. (2024); Smirnova et al. (2025); Wang (2024).
(61) Campbell (2023); Wang (2024).
(62) Levine et al. (2025); Olson (2002).
(63) Beck & Levine (2023); Levine et al. (2025); Yin (2024).
(64) Alsaedi (2024); Ghafouri et al. (2024); Kosmyna et al. (2025); Levine et al. (2025).
(65) Alsaedi (2024); Beck & Levine (2023); Wang & Fan (2025).
(66) Kosmyna et al. (2025); Levine et al. (2025); Marchetti et al. (2025); Tate et al. (2023).

Each stage in this table reflects how AI's role must be interpreted contextually, not universally. The same feature—such as rephrasing or sentence suggestion—can be either a support or a hindrance depending on when and how it is used. For instance, offering transitions may help a multilingual writer gain fluency during drafting, but if provided too early in the prewriting phase, it may suppress divergent thinking. Similarly, grammar correction may improve refining work, but if used without internal feedback loops, it may erode language learning over time, just as autocorrect spell checks can impede learning how to spell is relied on too heavily.

By making explicit these dual potentials, this analysis emphasizes the need for instructional mediation, developmentally appropriate AI use, and explicit goal-setting. This stage-by-stage mapping also reveals that ChatGPT's influence is not fixed; it is dynamic and contingent, reinforcing the broader argument that cognitive development depends not on the tool itself but on how, when, and why it is used.

What We Still Don't Know: The Blind Spot Behind General Offloading Claims

The reviewed literature identifies cognitive offloading as a concern in AI-supported writing but fails to define its boundaries (Bai et al., 2023; León-Domínguez, 2024; Luo et al., 2024). The history of science provides many examples of how cognitive offloading has led to a great deal of human development. For example, using a GPS can speed up the accuracy and arrive time of people to their destinations. While frequently cited, the term is rarely unpacked with precision. Rather than exploring what exact cognitive processes are offloaded, and at what cost, most studies emphasize ChatGPT's practical features such as efficiency, fluency support, or error correction. There is evidence that while the developmental impact of offloading is likely task-dependent, with evidence showing, that links between writing and cognitive development shift with task characteristics. For instance, self-regulation contributes most strongly during challenging tasks (Chandler et al., 2021). What remains unclear, therefore, is which cognitive processes, under which specific conditions, are replaced, reinforced, and/or erode due to ChatGPT use. The brain has limited ability to pay attention to memorize information and to therefore learn. The ability to offload some of its high energy tasks can be beneficial, but there are also drawbacks. This means there is quite possibly an upside to using ChatGPT depending on what we mean, precisely, by cognitive offloading.

Writing development depends on a layered set of cognitive skills as shown in Table 1, including inhibition, working memory, attention, planning, problem-solving, cognitive flexibility, Theory of Mind, and metalinguistic awareness. Each plays a different role depending on the stage of writing, and each deserves to be studied independently rather than treated as a general outcome. Most studies discussing ChatGPT and cognition refer to broad offloading effects but fail to analyze and explore how each specific cognitive process (McCutchen, 2006; Ruffini et al., 2024) might be supported or undermined by AI. This

absence of granularity makes it difficult to align instructional decisions with cognitive development goals.

Beyond these nuanced differences, the literature also reveals a conceptual mismatch between research questions and developmental relevance. Studies often frame their findings around performance indicators, such as writing speed, output quality, or student satisfaction. Few ask whether these indicators reflect authentic learning, or simply better outcomes with less thinking. This reflects a deeper pattern in the research landscape: what is measured is product, not process—performance is tracked, but transformation is not. It is also clear that cognitive offloading depends on the learner's level of understanding. As described in the calculator example, cognitive offloading when the student knows the math means increased speed, which is different from using the calculator without understanding the math, which means compromised rehearsal of core networks for learning.

Another gap lies in who is studied, revealing a major demographic bias. The majority of research conducted between ChatGPT's inception and the end of 2025, has typically centered on university students. Early writers whose executive functions are still maturing and who may be most vulnerable to the premature automation of cognitive effort (Uytun, 2018) have not been studied as much. This omission stems in part from challenges with studying young learners ethically and rigorously, and creates a dangerous blind spot. If tools automate too much during the formative years, essential skills may be displaced before they are fully formed. We cannot evaluate the true impact of AI writing assistants without understanding what cognitive work is being replaced and whether young learners are developmentally prepared to delegate that work.

Although ChatGPT is still a relatively new tool (OpenAI, 2022), its widespread uptake in schools increases the urgency of developmental research. Most of the reviewed literature

emphasizes immediate application of tools, rather than long-term impacts on cognition . Many authors now call for empirical research to replace assumption-driven enthusiasm with evidence-based guidance (Bai et al., 2023; León-Domínguez, 2024; Luo et al., 2024). Most current findings focus on short-term gains or general writing performance, without addressing long-term impacts on cognitive growth or identity development. This shift—from tracking use to understanding impact—is central to aligning AI integration with the developmental goals of writing education. Otherwise, we risk confusing adoption with learning, and shaping student thinking around tool performance, not cognitive growth. As new tools reshape how students write, we must ask not just what they produce, but what they practice, what they lose, what they gain and who they become.

These two expected and three unexpected findings raise more questions than answers and suggest that additional, longitudinal, experimental work must be done. Some of the boundaries around these new recommendations are framed by the answer to our initial question.

Conclusion

Answer to the Research Question

The aim of this literature review was to examine how and to what extent ChatGPT influences the cognitive development of developing writers in relation to the thought process behind writing. Due to the newness of the field, a great deal of inference was needed to piece together an answer based on the limited studies currently available which have mainly focused on university students. While the currently available literature does not allow to fully answer the question, the emerging consensus in the literature points toward a twofold insight.

First, ChatGPT likely has the capacity to influence the cognitive processes involved in writing among young learners, both in positive as well as in negative ways. The synthesis of literature suggests, and existing evidence supports that ChatGPT use during the writing process can influence cognitive development both stagnating as well as enhancing it. Second, that influence depends largely on how the tool is framed, scaffolded, and integrated into instructional practice. Like all important questions, the true answers lie in multi-faceted subtleties of the objective. If the objective is a speedily produced high quality product, ChatGPT can and should be used without question in all contexts, including young learners. If the objective, however, is to educate deep thinkers, then several conditions need important pre-requisite steps, especially for young learners. If the goal is to do both, which it appears to be, the pre-requisite steps multiply.

Taken together, these findings suggest the need for caution against oversimplified or premature interpretations of ChatGPT's impact on young writers. If our understanding is based only on abstract or untested hypotheses, without considering the realities of classroom context or the developmental readiness of learners, we risk falling into one of two extreme and misleading assumptions. The overly optimistic view assumes that ChatGPT can be perfectly integrated into writing instruction, enhancing cognitive development with no negative consequences simply because it is used alongside teachers or within structured settings. The overly pessimistic view assumes that ChatGPT will inevitably cause cognitive harm by enabling students to outsource their thinking, focus solely on the final product, and bypass the effortful processes of writing that build cognitive skills such as planning, revising, and metacognition. In other words, ChatGPT's impact is neither inherently positive nor negative; it depends on how it is used, by whom, at what stage of development, and under what kind of instructional guidance.

To fully grasp how and to what extent ChatGPT usage will impact young writers, there is a need to consider various usage scenarios and develop hypotheses that examine how specific cognitive functions are affected at distinct stages of the writing process as indicated in Tables 1, 2, and 3. Table 1 addresses *what* cognitive functions are involved, Table 2 shows *when* these functions are engaged across writing stages, and Table 6 considers *how* the influence of ChatGPT might be strengthened or mitigated. This level of specificity—linking cognitive processes with corresponding writing stages and potential influences—is essential to move beyond general assumptions and toward evidence-based understanding. Simultaneously, while research on how ChatGPT usage is influencing young writers is progressing slowly, we should act based on existing knowledge about child development and how writing affects their brain and cognitive abilities to guide current practices.

Implications of the Findings

The findings suggest that ChatGPT is revolutionizing our approach to literacy education and to teacher education, which suggests there is a need to shift how writing is taught to best support the development of the thinking behind writing. Based on the synthesis of the literature and acknowledging the limitations of current research, several recommendations can be cautiously proposed to address the potential cognitive implications of using ChatGPT in the writing processes of developing writers.

Firstly, it is crucial to ***emphasize process-oriented writing instruction*** across educational settings. Recognizing writing as a meta-skill underscores its importance across all areas of learning. The development and implementation of AI literacy programs appears essential. Tseng and Warschauer (2023) emphasize that AI literacy enables both educators

and students to understand, utilize, and critically evaluate AI technologies. By incorporating AI literacy into curricula from the earliest years of education, students may learn to interact effectively with AI tools like ChatGPT, recognizing capabilities and limitations of the tool. This approach could mitigate the risks of cognitive offloading, as students are guided to use AI as a supportive tool rather than a replacement for their own cognitive processes (Su & Yang, 2023).

Second, educators should ***integrate writing activities across the curriculum*** to strengthen this foundational ability. This approach not only enhances writing proficiency but also supports the development of critical thinking, problem-solving, and adaptability—skills essential for success in a future where the ability to learn and adapt quickly is crucial due to the ever-changing nature of work. Teacher education must not only include this shift in emphasis from product to process but also must support teacher AI literacy to encourage writing in all subjects. Focusing on the writing process engages students in comparing worked models for planning, drafting, revising, and reflecting, which are crucial for developing executive functions and critical thinking skills over the course of child development and into proficiency over the lifespan (Campbell, 2023; Hairston, 1982).

Furthermore, successful ***writing is not only dependent on the individual but relies on others in social contexts*** and can be considered a group activity when managed well (Graham, 2018). Vygotsky's ZPD (1978) underscored that learning is most effective when children are supported in tasks slightly beyond their independent ability. In the context of writing, educators can leverage this principle by scaffolding tasks with guided support, ensuring students progressively increasingly master complex writing processes in the company of others. Educators are encouraged to design writing assignments that promote active cognitive engagement at each stage. AI tools like ChatGPT can complement this

approach, acting as an additional scaffold that encourages cognitive growth when calibrated to provide just enough support to keep tasks within the learner's Zone of Proximal Development and without replacing the crucial role of teacher guidance. As indicated in stakeholder roles, there are several things that parents and teachers can do more of in the early years which would serve as protective factors against negative consequences of ChatGPT use, which are listed below.

Specific tasks for parents and teachers supported by the literature:

1. ***Begin where students are at, not where the textbook says.*** Use neuroconstructivist hierarchies. Begin with the writing stage, then target cognitive functions. It should be identified where the learner is in the writing process (Table 2 – when) and which cognitive functions (Table 1 – what) are most relevant at that stage. Table 6 should be used to anticipate how AI might support or hinder these functions.

2. ***Preserve productive struggle.*** Tasks should be designed within the learner's Zone of Proximal Development to maintain challenge, encourage persistence, and support gradual skill progression (Dweck, 2006; McCutchen, 2006; Vygotsky, 1978).

3. ***Embed formative feedback loops.*** Opportunities for teacher and peer feedback should be incorporated at multiple points to strengthen reflection, self-regulation, and strategic revision (Graham & Perin, 2007a; López et al., 2017).

4. ***Provide explicit instruction on AI use.*** Instruction should address when and why to use ChatGPT, how to structure prompts, and how to critically assess responses, embedding AI literacy into the learning process (Levine et al., 2025; Tseng & Warschauer, 2023).

5. **Use prompting as a meta-skill.** Iterative prompting should be encouraged, with students stating intentions, refining queries, and explaining why changes were made. This approach supports metacognitive control and intentional tool use (Tate et al., 2023; Wang, 2024).

6. **Verify outputs for bias and accuracy.** Strategies for identifying and addressing potential biases or factual inaccuracies in AI output should be scaffolded, guiding students to corroborate information with reliable sources (Dwivedi et al., 2023; Su & Yang, 2023).

7. **Protect student voice and authorship.** Students should be required to justify accepted AI suggestions and identify their own contributions to preserve ownership and identity development (Levine et al., 2025; Wang, 2024).

8. **Incorporate collaborative stages.** Peer discussion and joint problem-solving should be integrated at key points in the writing process to enhance idea generation and audience awareness (Rogoff, 1990), and co-designing curricular goals should be used to enhance agency (Fusco, 2024).

9. **Use AI to lower affective barriers while keeping human connection central.** AI may be employed for low-stakes, judgment-free practice to build confidence and persistence; however, human feedback should remain the primary driver of deeper learning (Alsaedi, 2024; Ghafouri et al., 2024).

10. **Reverse roles—treat AI as tutee.** Students can be asked to "teach" ChatGPT a concept or skill and then evaluate its response for accuracy and completeness. This "learning by teaching" approach supports deeper processing and metacognition (Su & Yang, 2023; Tate et al., 2023).

11. **Align AI-supported stages with developmental readiness.** AI-supported stages should be selected based on the learner's maturity and prior mastery, ensuring AI complements—rather than replaces—essential practice (Ruffini et al., 2024; Tokuhama-Espinosa et al., 2024).

A final important finding is that "A primary goal of education is to **empower students to become independent, self-directed learners across their lifespan**" (Cartwright et al., 2023, p. 312). Anchoring AI integration in this principle ensures that innovations serve the broader mission of education, rather than reducing it to efficiency or convenience. If deeper thinkers are a goal of formal education, then a more radical change in formal education will include a revision of how we measure "quality" in writing instruction. Teaching thinking through the teaching of writing can no longer be measured by a multiple choice test but will involve the assessment of cognitive growth over time.

Limitations of the Study

There are two important limitations that should be acknowledged to contextualize the findings and recommendations presented in this literature review. First and foremost, the authors recognize that the rapid pace of AI tool development presents a moving target for research. We have not been able to keep pace with the exponential flood of research on ChatGPT and writing, though we have done our best to ensure all relevant child emergent writer studies are included in this review. Studies included in this review may already be partially outdated given the speed at which ChatGPT and similar tools are evolving in terms of capabilities, accessibility, and integration into educational platforms. This limits the generalizability of findings over time and underscores the need for continuous monitoring and re-evaluation of implications as the technology changes. Second, due to the dearth of research conducted on the youngest learners, the analysis draws on conceptual models of cognitive functions and writing stages (Tables 1–3) to interpret potential ChatGPT impacts based on guides from developmental psychology, and the neuroconstructivist stages of writing, rather than from direct studies. While these models are grounded in established literature, their specific application to AI-mediated writing in young learners has not yet been empirically validated. Until these hypotheses are tested with the target age group, the conclusions should be considered preliminary, awaiting empirical confirmation, and subject to refinement.

Findings Related to Stakeholder Involvement

Achieving the conditions outlined in the preceding criteria will require coordinated action from all parties engaged in supporting young learners. No single group can ensure the developmentally appropriate integration of ChatGPT in writing instruction; rather,

success depends on aligned efforts across the educational ecosystem. This section outlines how each stakeholder group can operationalize the principles presented in the preceding criteria, adapting them to their specific roles and local contexts.

- ***Parents and guardians:*** **Key contributions** may include promoting balanced AI use, encouraging fact-checking, and reinforcing the value of the writing process beyond schoolwork. They are important partners in supporting their children's learning. Many express both excitement about ChatGPT's potential to enhance learning and creativity, and concern about its impact on child development. Striking a balance between benefits and risks—particularly in preserving curiosity and open-mindedness—is essential. Child caregivers can offer clear boundaries, active involvement in how children use AI tools, and staying informed about tool possibilities and limitations can help address these concerns. As a child's first teacher, to date, the best advice remains reading to children from the moment they can hear to build vocabulary, encourage drawing, and promote storytelling, foundations for early writing.
- ***Educators and teachers:*** **Key contributions** may include adapting the evidence-based criteria—such as aligning AI use to developmental readiness, embedding AI literacy, and ensuring verification for bias—to classroom realities. Educators play a pivotal role in implementing process-oriented instruction and guiding students in the responsible use of AI tools. Professional development opportunities can equip them with the skills and knowledge to make AI integration both effective and developmentally

appropriate (Kervin et al., 2020). A first step is to become AI literate to support students.

- ***School leaders and curriculum designers:*** **Key contributions** are in their role to translate the criteria into institutional policies, professional learning plans, and curriculum design that reinforce writing as a cross-curricular meta-skill. They are instrumental in creating the structural and policy frameworks that enable responsible AI integration.
- ***Government and educational institutions***: **Key contributions** are to offer guidelines that should be developed at a societal level rather than relying solely on individual efforts, as systemic change is necessary to create lasting impact. The development of ChatGPT and other conversational AI is progressing faster than the evolution of education systems and guidelines. Acting now, rather than later, is crucial to prevent unintended consequences. While it is impossible to predict every future scenario, proactively creating regulatory and instructional frameworks can both mitigate risks and promote the positive, developmentally appropriate use of AI. have the capacity to support these initiatives through policy development, funding for research, and integration of AI literacy into educational standards.
- ***Researchers:*** **Key contributions** include investigating developmental readiness for AI-supported tasks, identifying how young learners become aware of bias and hallucinations in AI outputs, and examining the long-term cognitive effects of sustained AI use. Collaboration with educators, technologists, and policymakers ensures that research findings translate into actionable, developmentally appropriate practices. Researchers play a critical

role in closing the knowledge gaps that currently limit evidence-based guidance for AI integration in early writing instruction. To address these gaps, their work should focus on testing and refining the principles outlined in the criteria, particularly in areas where current evidence is limited.

- ***Students (developing writers):*** **Key contributions** are to remember "the person who does the work is the person who does the learning," (Tokuhama-Espinosa, 2024). This suggests students themselves should be included in discussions about AI usage, fostering their self-awareness and encouraging them to be active participants in their learning processes. They can engage with the criteria by setting learning goals before using AI, evaluating AI suggestions critically, and reflecting on how the tool shapes their thinking.
- ***Technology developers***: **Key contributions** relate to focusing on creating educational AI products that support the writing process rather than simply delivering final products. They hold a critical role in designing AI tools that are pedagogically sound and developmentally appropriate, taking into consideration the cognitive needs of young users. By collaborating with educators and cognitive scientists, they can use the criteria as design benchmarks, ensuring that tools promote process-oriented writing, metacognition, and developmental readiness, and avoid reducing writing to a product-oriented task.

Through open dialogue and collaboration among these stakeholders, AI tools like ChatGPT can be integrated in ways that enhance learning while safeguarding the cognitive development of young writers, ultimately preparing children to navigate a future where AI is an integral part of life.

Recommendations For Future Studies

There is a pressing need to ***conduct long-term, empirical research*** to fill the gaps identified in the current literature. The lack of empirical studies examining the long-term cognitive effects of AI writing assistants on young children is a significant limitation (Bai et al., 2023; Luo et al., 2024). As such of the existing evidence on AI-assisted writing comes from studies with older students, meaning that findings for 5–11-year-olds remain largely inferred. Researchers are encouraged to undertake longitudinal studies to investigate how continuous interaction with ChatGPT affects specific cognitive functions involved in writing. Such research would provide valuable insights to inform evidence-based educational practices. This review relied on secondary sources, synthesizing existing empirical studies instead of conducting new experimental or longitudinal research. This introduces an inherent dependence on the accuracy, quality, and scope of the studies cited, as well as the potential for publication bias favoring certain outcomes or perspectives. The synthesis aimed to mitigate this by cross-referencing multiple studies and integrating findings from cognitive science, educational psychology, AI literacy and educational technology research; however, the absence of first-hand empirical data limits the ability to draw definitive causal conclusions.

While we await these studies, ***educators and policymakers should apply existing knowledge about child development and the cognitive impacts of writing to guide the integration of ChatGPT*.** By balancing ongoing research efforts with the application of established principles, we can ensure that AI tools are used in ways that support cognitive development while also deepening our understanding through empirical evidence.

Finally, adopting a ***transdisciplinary approach*** is considered the most effective way to strategize on the complexity of writing instruction in the era of ChatGPT where necessary.

Since the challenges posed by integrating AI into education span multiple domains, collaboration among educators, neuroscientists, cognitive psychologists, technologists, and ethicists is necessary. Wicked problems, such as educational goals to develop deep thinkers through the writing process (Leverenz, 2014), suggest that this collaborative effort may lead to the development of comprehensive guidelines that balance technological innovation with developmental needs (León-Domínguez, 2024). In the best of all worlds, this could exist through the development of transdisciplinary teams who could work together to create instructional strategies that effectively integrate AI tools while prioritizing cognitive development; or possibly through individual researchers who use a transdisciplinary research lens to develop interventions.

In addition to these recommendations by these key stakeholders, this fastmoving ChatGPT emergent writer conversation points to some areas on the horizon, listed below under what remains uncertain.

What remains uncertain

1. **Developmental readiness for prompting as a meta-skill**. No empirical studies determine the age or conditions under which children can use prompting to meaningfully support metacognition.

2. **Bias detection in young learners**. It is unclear whether children aged 5–11 can reliably identify and correct for AI bias without explicit scaffolding.

3. **Long-term cognitive impacts**. There is no longitudinal evidence tracking the effects of sustained ChatGPT use on the development of writing-related cognitive skills.

4. **Optimal balance of AI and human feedback**. The proportion and timing of AI feedback that complements—rather than competes with—teacher guidance remain unknown.

5. **Transfer of benefits across disciplines**. More evidence is needed on whether AI-supported writing improves cognitive skills in other domains, such as problem-solving in science or mathematics.

Future Research Suggestions

Given the need for longitudinal work and therefore slow progression of research on how ChatGPT usage influences young writers, there is a crucial need for empirical studies that build upon established knowledge about child development, particularly how writing affects the brain and cognitive abilities. Important steps forward include examining specific cognitive processes at different stages of the writing process, exploring varied usage scenarios, developing robust and age-appropriate research methodologies, and assessing long-term cognitive effects of sustained AI use. As these studies are conducted, educators should continue to apply existing knowledge to support cognitive development in the integration of ChatGPT, updating instructional practices as new evidence emerges.

Several research priorities emerge from the gaps identified in this review:

1. **Developmental readiness** for **prompting as a meta-skill** – Determining the age and instructional conditions under which children can use prompting to support metacognitive control effectively.
2. **Awareness of bias and hallucinations** – Investigating how, and at what developmental stages, young learners become capable of recognizing and questioning bias or factual inaccuracies in AI-generated outputs.

3. **Long-term cognitive impacts** – Conducting longitudinal studies to examine how sustained AI-assisted writing influences the development of core writing-related cognitive functions such as planning, revising, and self-monitoring.
4. **Optimal balance of AI and human feedback** – Identifying how the timing, proportion, and integration of AI-generated feedback and teacher feedback can preserve cognitive challenge and foster skill progression.
5. **Transfer effects across domains** – Evaluating whether cognitive benefits gained from AI-supported writing extend to other academic and problem-solving contexts.

Because the complexity of integrating AI like ChatGPT into education exceeds the capacity of any one individual discipline, a transdisciplinary research approach—combining cognitive science, educational psychology, instructional design, and AI ethics—will be essential to address the full range of challenges and opportunities this technology presents.

General Summary

As with all new technologies, the introduction of ChatGPT generates extreme responses at both ends of the spectrum. On one hand, there is fear and reluctance to use it (e.g. Alkaissi & McFarlane, 2023; Kosmyna et al., 2025; Tseng & Warschauer, 2023); and on the other, enthusiasm and a willingness to adopt it due to its potential to personalize education (e.g., Luo et al., 2024; Tseng & Warschauer, 2023; Wang, 2024). However, like any tool, adopting a stance of skeptical optimism is advised as such a balanced approach embraces innovation while exercising caution.

This literature review set out to explore the neurocognitive implications of integrating ChatGPT into the writing processes of children aged 5–11. This year-long literature review spanning ChatGPT's inception to the end of 2025 revealed little experimental evidence on

children, but a great deal of insight from cognitive neuroscience, child development, technology, and best practices in writing instruction, which informed an answer to the research question.

The potential of ChatGPT to support learning and foster creativity is immense. It can help address the once-dreamed-of need for one-on-one tutoring for every learner, providing personalized scaffolds at various stages of the writing process. Yet, without intentional design and oversight, its integration risks turning children into participants in an uncontrolled experiment, with unknown long-term impacts on their cognitive, social, and emotional development, a concern echoing earlier debates on smartphone use. Due to the complexity of the AI-education relationship, use of a transdisciplinary perspective is helpful. As Aristotle is attributed with saying, “the whole is, indeed, greater than the sum of its parts,” urging a multi-faceted and transdisciplinary approach to research on this topic. By synthesizing insights from diverse disciplines, we can tell a new story about the role of AI in education—one that promotes innovation while preserving the fundamental processes that nurture critical thinking and cognitive growth. Embracing skeptical optimism allows for balancing the benefits of innovation with the necessity of caution, ultimately supporting the cognitive development of future generations. Ensuring that writing is properly cultivated in young learners is crucial for their ability to think and therefore, learn, adapt, and thrive in a future where required skills are constantly evolving. This balanced approach, underpinned by collaboration and continuous research, can help mitigate risks and promote the positive use of AI in education. By acting now, stakeholders can ensure that AI integration benefits children’s learning and development, preparing them for a future where AI is an integral part of daily life and work. The evidence also supports a handful of evidence-based guidelines for responsible AI use with young children.

Addressing these challenges requires aligned contributions from all stakeholders including educators, parents, school leaders, policymakers, researchers, students, and technology developers. The preliminary criteria outlined in this paper offer a starting point for developmentally appropriate integration, while the stakeholder framework translates these principles into actionable roles. Research gaps remain significant, especially around long-term implications for developmental readiness for prompting as a meta-skill, children's awareness of bias and hallucinations, long-term cognitive effects, and the transfer of AI-supported writing benefits to other domains.

Establishing best practices for responsible AI use, considering developmental needs, and creating environments that foster learning and exploration while avoiding the risks of overexposure or misuse are essential steps. We hope this small contribution can contribute to the ongoing revolution in educational policy around emergent writers and ChatGPT in school settings. Ongoing research and regular updates to guidelines should be part of this process to adapt to new discoveries and technological changes.

The findings of this literature review suggest that ChatGPT's influence on young writers is neither inherently beneficial nor harmful; instead, its impact depends on how, when, and why it is used. The synthesis identified that writing—understood here as a meta-skill supporting critical thinking, executive functions, and adaptability—should remain central in any integration strategy. When paired with process-oriented instruction, explicit AI literacy, and safeguards for authorship and cognitive engagement, ChatGPT can serve as a scaffold that enhances learning. Conversely, when it shortcuts planning, revising, or metacognitive reflection, it risks undermining the very skills it might otherwise support.

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Conflict of Interest

We have no known conflict of interest to disclose.

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