



BEYOND THE EDUCATIONAL LOOP: GENERATIVE STRUGGLE IN AI-MEDIATED ENGLISH LANGUAGE ACQUISITION

Além do Ciclo Educacional da IA: Esforço
Generativo na Aprendizagem da Língua
Inglesa Mediada por Inteligência Artificial

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ABSTRACT | Background: This study develops *generative struggle* as a pedagogical framework for AI-mediated English language acquisition, addressing the cognitive risks associated with AI-driven task completion and cognitive offloading. **Objective:** The study aims to: (1) identify psychological barriers that may influence learners' engagement with their own cognitive resources during AI-mediated writing tasks, and (2) conceptualise the teacher's role as an epistemic mentor who promotes generative struggle, divergent thinking, learner agency, and meaningful language development in GenAI-assisted writing environments. **Methods:** The study adopts a conceptual and theoretical synthesis approach, integrating perspectives from cognitive psychology, second language acquisition, English language teaching, and educational technology. The inquiry draws on five established traditions: the generation effect, desirable difficulties, writing-to-learn, error-based learning, and cognitive offloading. These perspectives are considered alongside the learner-centred vision of NEP 2020 to examine the relationship between cognitive effort and meaningful language development. **Results:** The analysis suggests that excessive reliance on algorithmic efficiency may erode cognitive engagement by bypassing the generative struggle central to language acquisition. The proposed framework therefore prioritises generative struggle and guided self-correction over mere task completion, repositioning the teacher as an epistemic mentor who fosters reflective, metacognitive, and critical engagement beyond the "impressiveness trap." Rather than rejecting automation, the framework advocates pedagogically mediated AI integration that supports generative learning while limiting cognitive outsourcing. These findings provide a basis for preliminary instructional directions adaptable to learners' proficiency levels, institutional contexts, and assessment designs. **Conclusion:** The paper conceptualizes *generative struggle* as an integrative construct that synthesizes five established cognitive traditions to explain learning under AI-mediated conditions. The concepts of the *AI education loop* and the *impressiveness trap* further illuminate emerging tensions between AI-assisted performance, cognitive engagement, and genuine learning. Together, these concepts provide a conceptual basis for understanding how AI-mediated educational environments can support meaningful learning without displacing the cognitive effort essential to language development.

Keywords | AI Education Loop, Generative Struggle, Educator as Facilitator, Error-Driven Pedagogy, Productive Failure.



RESUMO | Contexto: Este estudo desenvolve o conceito de esforço generativo como uma estrutura pedagógica para a aprendizagem da língua inglesa mediada por inteligência artificial, considerando os riscos cognitivos associados à realização de tarefas por IA e à transferência de processos cognitivos para sistemas automatizados. **Objetivo:** O estudo busca: (1) identificar barreiras psicológicas que podem influenciar o envolvimento dos estudantes com seus próprios recursos cognitivos durante atividades de escrita mediadas por IA; e (2) conceituar o papel do professor como mentor epistêmico, capaz de promover esforço generativo, pensamento divergente, agência do estudante e desenvolvimento linguístico significativo em ambientes de escrita apoiados por IA generativa. **Métodos:** O estudo adota uma abordagem de síntese conceitual e teórica, integrando perspectivas da psicologia cognitiva, aquisição de segunda língua, ensino da língua inglesa e tecnologia educacional. A análise articula cinco tradições teóricas consolidadas: efeito de geração, dificuldades desejáveis, escrita para aprender, aprendizagem baseada em erros e transferência cognitiva para recursos externos. Essas perspectivas são examinadas em conjunto com a abordagem centrada no estudante prevista pela Política Nacional de Educação da Índia (NEP 2020), com o objetivo de compreender a relação entre esforço cognitivo e desenvolvimento linguístico significativo. **Resultados:** A análise sugere que a dependência excessiva da eficiência algorítmica pode comprometer o engajamento cognitivo ao suprimir o esforço generativo inerente ao processo de aquisição de uma língua. A estrutura proposta, portanto, prioriza o esforço generativo e a autocorreção orientada em detrimento da simples conclusão de tarefas, reposicionando o professor como mentor epistêmico responsável por estimular o engajamento reflexivo, metacognitivo e crítico para além da denominada "armadilha da aparência de competência". Em vez de rejeitar a automação, a proposta defende uma integração pedagogicamente mediada da IA, capaz de favorecer a aprendizagem generativa e, simultaneamente, limitar a terceirização de processos cognitivos. Os achados fornecem uma base para orientações didáticas preliminares, passíveis de adaptação aos níveis de proficiência dos estudantes, aos diferentes contextos institucionais e aos modelos de avaliação. **Conclusão:** O estudo conceitua o esforço generativo como um construto integrador que reúne cinco tradições consolidadas da psicologia cognitiva para explicar a aprendizagem em contextos mediados por IA. Os conceitos de ciclo educacional da IA e armadilha da aparência de competência contribuem, ainda, para compreender as tensões emergentes entre desempenho assistido por IA, engajamento cognitivo e aprendizagem efetiva. Em conjunto, esses conceitos oferecem uma base teórica para compreender de que maneira ambientes educacionais mediados por inteligência artificial podem favorecer aprendizagens significativas sem substituir o esforço cognitivo essencial ao desenvolvimento linguístico.

PALAVRAS-CHAVE | Ciclo Educacional da Inteligência Artificial; Esforço Generativo; Educador como Facilitador; Pedagogia Baseada em Erros; Fracasso Produtivo.

INTRODUCTION

The growth of the AI education loop

Artificial intelligence (AI) is rapidly transforming educational practices, particularly through the emergence of generative AI (GenAI) and large language models (LLMs). In language education, tools capable of generating, revising, translating, and evaluating text have created new possibilities for supporting learners and teachers. AI-mediated writing environments can facilitate access to linguistic resources, provide immediate feedback, and assist learners in completing tasks that previously required substantial individual effort. At the same time, however, the increasing capacity of AI systems to perform cognitive and linguistic tasks raises questions about what learners may gain or lose when responsibility for these processes is transferred to algorithms.

The growing integration of GenAI into educational practices has also contributed to what may be described as an AI education loop: teachers use AI to design or adapt learning materials, learners use AI to generate or improve responses, and educational processes increasingly rely on



AI-supported evaluation and feedback. Although such integration may increase efficiency, it may also create a situation in which visible academic performance improves without a corresponding development of learners' independent reasoning, linguistic competence, or ability to engage critically with knowledge. The central issue is therefore not whether AI should be used in education, but how its use can be structured so that technological assistance does not displace the cognitive processes through which meaningful learning occurs.

The Problem: Cognitive Effort and the Impressiveness Trap

This concern is particularly relevant to language learning, where writing involves more than the production of grammatically accurate text. Writing can require learners to generate ideas, make linguistic choices, evaluate alternatives, respond to feedback, and revise their formulations. These processes involve cognitive effort and can contribute to language development. When AI generates highly polished responses with minimal learner effort, however, learners may have fewer opportunities to engage in these processes themselves.

Krashen (1982) emphasizes the role of comprehensible input in SLA, while Swain (1995) highlights written output as an opportunity for learners to notice linguistic gaps, test hypotheses, and internalize new language. Thus, writing serves as a space for reflection, experimentation, and language development.

This tension gives rise to what this study conceptualises as the "impressiveness trap": the possibility that the fluency, sophistication, and apparent quality of AI-generated content (AIGC) may create an impression of learning that exceeds the learner's actual cognitive and linguistic engagement with the task. The issue is therefore not simply the accuracy or usefulness of AI-generated output, but the relationship between task completion, cognitive effort, and learning. If learners increasingly outsource processes such as idea generation, linguistic formulation, revision, and evaluation, AI-assisted performance may become increasingly detached from the development of the learner's own cognitive and linguistic resources.

The problem becomes particularly significant in AI-mediated writing, where the distinction between assistance and cognitive outsourcing may be difficult to establish. The challenge for language education is consequently to identify pedagogical conditions under which AI can support learning while preserving the productive cognitive effort associated with independent generation, reflection, evaluation, and revision.

Research Gap and Research Questions

Despite the rapid expansion of research on AI-assisted language learning, important questions remain concerning the cognitive conditions under which GenAI can contribute to meaningful language development. Existing research has established the potential of AI to support language-related tasks, while broader scholarship has raised concerns about cognitive offloading (Jose et al., 2025), critical AI pedagogy (Aquino, 2026), creativity (Runco, 2023, 2025), metacognitive engagement,



and the changing role of teachers (Edelouei, 2025). However, these perspectives have not yet been sufficiently integrated into a conceptual account of how cognitive effort might be deliberately preserved within AI-mediated language learning.

There remains a need to conceptualise the relationship between AI-assisted task completion and the productive cognitive effort involved in generating, evaluating, and revising language. There is also a need to clarify how teachers can mediate this relationship rather than functioning primarily as facilitators of AI access. This study addresses these gaps by bringing together perspectives from cognitive psychology, second language acquisition (SLA), English language teaching (ELT), and educational technology.

The study therefore develops generative struggle as a conceptual framework for AI-mediated English language learning. Rather than viewing cognitive effort as an obstacle to efficiency, the framework considers productive engagement with difficulty as a potentially important condition for meaningful learning. Thus, it conceptualizes the teacher as an epistemic mentor capable of designing and mediating AI-assisted writing tasks so as to foster learner agency, divergent thinking, self-correction, and critical engagement.

The proposed framework should not be understood as a definitive account of AI-mediated language learning, but as a conceptual basis for further investigation. Its propositions and instructional directions remain open to empirical validation, refinement, and extension across diverse educational contexts.

The study addresses the following research questions:

- a. What psychological barriers may influence learners' engagement with their own cognitive resources when undertaking writing tasks?
- b. How can teachers function as epistemic mentors in GenAI-assisted writing environments to promote generative struggle, divergent thinking, learner agency, and meaningful language learning?

LITERATURE REVIEW

AI-Mediated Language Learning: Affordances and Limitations

Sumakul et al. (2022, p. 249) suggested that AI could be a supportive tool in educational contexts. Their findings indicate that teachers retain autonomy in selecting and implementing technological tools in instructional practices. The four EFL teachers from a university in Indonesia, acknowledged that AI can assist teachers in instruction and support students in their learning processes. Furthermore, their analysis identified two key conditions for successful integration of AI in language classrooms: students' motivation levels and teachers' technological and pedagogical competence.

Although these conditions seem encouraging, they may not be sufficient in themselves. A critical question therefore remains: can student motivation and teacher expertise alone ensure the effective integration of traditional pedagogy and advanced technological innovations? This raises further questions about whether the integration of AI necessarily leads to uniformly



enhanced learner performance (Guo et al., 2024) or diminishes teachers' instructional role. Rather than creating "super learners" or rendering teachers redundant, it is essential to examine the pedagogical responsibilities of educators and the limitations of AI-assisted instruction. According to Baskara (2023) and Agustini (2023), as cited in Al-Khresheh (2024), ChatGPT can enhance learner engagement, personalize learning, and accelerate language acquisition, while its integration also presents pedagogical, cultural, and logistical challenges. These concerns are reflected in the emerging "AI education loop," where AI increasingly mediates teaching, learning, and assessment, potentially weakening learners' independent linguistic and cognitive development.

Recent empirical evidence suggests that AI-mediated language instruction yields significant pedagogical benefits. In a 10-week longitudinal study grounded in Vygotskian social constructivism, Wei (2023, p. 11) investigated the impact of the AI platform Duolingo on 60 Chinese university EFL students. The findings indicated that AI-integrated instruction positively correlated with English learning achievement, second language motivation, and enhanced self-regulated learning behaviour. However, a critical disconnect exists between these localized experimental successes and broader international educational policies and the use of AIGC in the real world (Guo et al., 2024).

Recent studies on GenAI in education also identify concerns related to the erosion of learners' epistemic agency, over-reliance on automation, and reduced self-regulated cognitive effort. Kasneci et al. (2023) argue that while LLMs can support personalization, accessibility, and instructional assistance, they simultaneously introduce risks associated with conceptual superficiality, plausible misinformation, and decreased student active participation in the knowledge-building process.

This study employs a sociotechnical and pedagogical critique through an integrated theoretical framework. Runco's (2025) notion of pseudo-creativity distinguishes automated synthesis from genuine thought in AI-mediated learning. CLT illuminates how information presentation shapes intellectual performance, while EA and generative theory reconceptualize student errors as developmental markers rather than failures. Together, these perspectives clarify how AI intersects with cognition, instructional design, and SLA.

Runco's Pseudo-creativity

Creativity remains a cornerstone of individual and societal progress, as echoed by the National Education Policy (NEP) 2020, which prioritises conceptual understanding, critical thinking, and resilient communication (Gupta and Chatterjee, 2023, p. 12). However, the rise of GenAI threatens this advancement. While GenAI can simulate creative output, its underlying processes often bypass the cognitive rigour required for authentic creativity (Runco, 2025). The danger lies in a potential "pedagogical shift": if educators mistake artificial mimicry for genuine innovation, they risk devaluing the human struggle inherent in the creative process. By rewarding algorithmic shortcuts rather than authentic cognitive exploration, we may inadvertently stifle the very resilience and divergent thinking that NEP 2020 aims to cultivate (Runco, 2025, p. 2).



Applying Runco's (2025) framework of pseudo-creativity, AI-assisted writing can be seen as reducing learners' engagement in the cognitive processes associated with creativity, particularly divergent thinking. If creativity is understood as an intellectual trajectory marked by conceptual tension, hypothesis formation, and reflective revision, then uncritical reliance on AI risks limiting participation in these formative processes. Students may therefore fail to cultivate deeper creative competencies, functioning instead as mediators of automated synthesis, which could constrain long-term intellectual growth (Runco, 2025, p. 3).

Pseudo-creativity, automation, and the illusion of competence

Although Runco (2023; 2025) argues that AI systems only simulate pseudo-creativity, recent studies on GenAI suggest that the central pedagogical problem lies not exclusively in automated production itself, but in the growing dissociation between apparent performance and underlying cognitive competence. Kasneci et al. (2023) note that tools such as ChatGPT can increase textual fluidity, productivity, and accessibility, but they also reduce the visibility of the mental processes involved in learning, making it more difficult to distinguish genuine comprehension from plausible statistical reproduction. They report that utilizing LLMs in generating information within no time can adversely impact learners' critical thinking and problem-solving skills (p. 7).

This concern brings pseudo-creativity closer to phenomena discussed in the literature on "automation bias" and "epistemic dependency", in which learners come to rely excessively on automated systems even when they lack the necessary skills to critically evaluate the results produced (Mosier and Skitka, 1996; Risko and Gilbert, 2016). Thus, pseudo-creativity should not be understood only as an absence of originality, but as a form of cognitive outsourcing in which the final product appears sophisticated without necessarily involving deep conceptual elaboration.

Recent research in AI-mediated education also indicates that the language fluency produced by LLMs can mask important metacognitive gaps among entry-level learners, particularly in EFL and SLA settings (Kasneci et al., 2023; Zhai, 2023). Thus, the central concern is not the replacement of human creativity by AI, but the possibility that students will start to confuse polished linguistic production with effective intellectual development.

Cognitive Load Theory (CLT)

According to Lin and Chen (2006), as cited in Assis Hornay (2021, p. 43), the CLT asserts that the optimal presentation of information is crucial for improving intellectual performance. In the realm of SLA, learners frequently engage in intricate tasks that may surpass their constrained working memory capacity. Although the incorporation of AIGC aims to alleviate cognitive strain, it presents a noteworthy pedagogical dilemma.

As noted by Jose et al. (2025, p. 1), while AI-powered tools facilitate cognitive offloading the use of external resources to achieve mental tasks they simultaneously bypass the processes of active recall and problem solving. These processes are foundational pillars of cognitive development.



Furthermore, an overreliance on AI tools threatens to diminish the germane cognitive load the mental effort dedicated to processing and constructing permanent schemas (p. 2). By eroding this germane load, AI dependency may inadvertently stifle the development of higher-order thinking skills and prevent the “deep learning” required for sophisticated communication.

The CLT distinguishes between intrinsic load, extrinsic load, and germane cognitive load, a distinction particularly relevant for AI-mediated environments. While automated tools can reduce some of the extrinsic burden associated with searching for and organizing information, they also reduce the germane load, that is, the productive mental effort directed at schema construction, which is responsible for the active construction of enduring cognitive schemas (Sweller et al., 2011; Tlili et al., 2023, p. 19). In linguistic learning, an instructional paradox is created: the more efficient the tool in the immediate production of responses, the less the learner’s involvement can be in the cognitive processes necessary for linguistic internalization and conceptual reorganization. From a CLT perspective, reducing unnecessary extraneous load may, in some contexts, create cognitive space for deeper conceptual processing rather than merely diminishing effort.

From this perspective, the central pedagogical issue is not simply to reduce cognitive effort, but to differentiate between unproductive effort and generative effort. Excessive automation can eliminate precisely the processes of retrieval, formulation and revision that underpin the consolidation of long-term memory and the development of linguistic autonomy.

Desirable difficulty and generative effort

The notion that deep learning requires meaningful cognitive effort is supported by the concept of “desirable difficulty,” developed by Bjork and Bjork (2011, p. 58). According to this perspective, learning conditions that introduce moderate challenges, such as retrieval practice, independent response generation, and spaced revision, may initially reduce immediate performance but enhance long-term retention and transfer. Cognitive discomfort, therefore, is not an obstacle to learning but one of its central mechanisms.

When AI tools bypass stages of formulation, trial, error, and revision, they reduce the very difficulties that foster memory consolidation and conceptual restructuring. While such simplification enhances efficiency, it may weaken the generative processes essential for durable schema construction. Thus, apparent productivity gains may in fact diminish the cognitive conditions required for stable, transferable learning. Responsible AI integration thus requires preserving and even intentionally structuring productive levels of desirable difficulty. Rather than replacing generative effort, technology should be used to provoke analysis, justification, and conceptual reconstruction, maintaining the germane cognitive load essential for intellectual development (Sweller et al., 2011; Tlili et al., 2023).

These considerations are particularly relevant to second language acquisition, where learning depends not only on exposure to comprehensible input but also on learners’ active engagement in producing, testing, revising, and restructuring language. Written production can create opportunities for learners to notice gaps in their interlanguage, formulate hypotheses,



receive feedback, and revise their linguistic choices, thereby making the processes of language development more cognitively visible (Swain, 1995; Suzuki et al., 2019). Research on writing modality also suggests that the physical act of writing may influence memory processes: Mangan et al. (2015) found that handwriting was associated with better free recall of written material than keyboard-based writing, suggesting that active engagement with the writing process may have cognitive consequences beyond the production of the final text. From this perspective, the pedagogical concern with generative effort extends beyond general cognitive development: when AI completes substantial portions of the formulation and revision process, it may reduce learners' opportunities to engage in the productive struggle through which linguistic knowledge is progressively internalized. AI-mediated writing should therefore be designed not merely to improve the quality of the final text, but to preserve the cognitive and linguistic processes through which learners develop greater autonomy and control over the target language.

Error Analysis

To dismantle the myth that "writers are born, not made", we must focus student attention on the mechanics of the craft as a pathway to intellectual maturity. The ultimate objective of composition is not the completion of the final manuscript but the development of a particular cognitive profile. Writing is the way in which a student learns to think clearly, make strong arguments, weigh evidence, and stay focused on complex issues (Emig, 1977, p. 125). Outsourcing tasks to AIGC completely bypasses these crucial developmental milestones.

Drawing on Corder's (1967) foundational work, we advocate error analysis as a transformative pedagogical tool. By viewing errors not as failures but as critical indicators of a learner's "interlanguage system." We can guide students through the recursive stages of writing: prewriting, drafting, revising, editing, and publishing. While experienced writers can use AI to improve their existing knowledge and language skills, students need to build their own knowledge base first. By engaging deeply with the factors of production in writing (Raimes, 1983) learners can develop the "human-in-the-loop" expertise necessary to govern technology rather than be governed by it. Recent empirical research on error analysis and interlanguage has highlighted the potential of these approaches for understanding the processes involved in second language acquisition (SLA), particularly in English language learning (Sarkar, 2026). Building on the contributions presented in the literature, the discussion can be extended beyond the traditionally diagnostic function of error analysis to incorporate the concept of "productive struggle" as a potential mechanism for AI-mediated English language acquisition.

Policy and Critical Perspectives on Educational AI

Many countries have begun to reconsider the role of digital technologies in education despite their perceived benefits. Sweden provides a notable example of this policy shift. The Swedish Government has removed the requirement for children to use digital learning tools in preschool and has promoted greater use of non-digital educational activities, particularly for



younger learners (Government Offices of Sweden, 2024). This policy shift represents a departure from the earlier emphasis on the widespread digital transformation of teaching and learning in schools and educational institutions.

National Education Policy 2020 (Clause 23.3) similarly advocates the integration of technology in education while emphasizing that technological interventions must undergo rigorous evaluation within relevant contextual settings before large-scale implementation. This position closely aligns with the study's emphasis on sustained human mentorship and pedagogically guided AI integration (Ministry of Education, 2020).

METHODOLOGY

This study adopts a conceptual and theoretical synthesis approach rather than an empirical research design. The purpose of the literature synthesis was to identify, examine, compare, and conceptually integrate scholarship relevant to GenAI, ELT, SLA, cognitive load, cognitive offloading, productive failure, desirable difficulties, writing-to-learn, error-based learning, creativity, learner agency, and teacher mediation. The review process involved a structured search and screening of relevant literature, followed by a critical and thematic synthesis of selected sources. Accordingly, the study does not aim to provide an exhaustive or statistically aggregated review of the literature, but rather to develop a theoretically grounded account of how AI-mediated writing may affect learners' cognitive engagement and how teacher mediation can help preserve generative effort.

Relevant literature was identified through searches of Scopus and ERIC as supplementary indexed databases, alongside Google Scholar and ResearchGate. Additional relevant sources were identified through backward reference searching and citation chaining of key publications. These complementary search strategies were used to broaden the identification of relevant scholarship across established research literature and emerging discussions concerning AI-mediated education. Academic conferences, faculty development programmes, and webinars addressing AI, educational technology, AI ethics, language education, and learning were also considered as supplementary avenues for identifying emerging debates and relevant scholarship, rather than as independent sources of empirical data. ResearchGate was used as a supplementary discovery and access platforms rather than as substitutes for indexed bibliographic databases, particularly to locate emerging, interdisciplinary, or otherwise difficult-to-access scholarship.

The primary search focused on scholarly publications from 2001 to 2025, with particular attention to research published between 2022 and 2025 on *generative AI, ChatGPT, AI in education, AI-mediated language learning, ELT, SLA, cognitive load, cognitive offloading, productive failure, desirable difficulties, writing-to-learn, error-based learning, pseudo-creativity, teacher agency, AI ethics, and human-in-the-loop education*. Earlier publications were selectively retained when they represented seminal theoretical or pedagogical contributions necessary to establish the conceptual foundations of the study, including Corder (1967) on the significance of errors, Emig (1977) on writing as a mode of learning, Slamecka and Graf (1978) on the generation effect, Swain



(1995) on the role of output in second language learning, Raimes (1983) on writing instruction, and Mosier and Skitka (1996) on human decision-making and automated decision aids.

The search process identified approximately 250 potentially relevant sources. These sources were subsequently screened for conceptual and thematic relevance to the study. Following the screening and selection process, 49 sources were retained and incorporated into the final conceptual synthesis. Selection was guided by the relevance of each source to one or more of the study's central domains, particularly cognitive engagement, AI-mediated writing, generative struggle, learner agency, creativity, SLA, and teacher mediation. Sources that were not sufficiently relevant to these domains or did not directly contribute to the research questions and conceptual framework were excluded from the final synthesis.

The final body of literature was purposively and critically synthesized rather than statistically aggregated. The analysis focused on identifying convergences, tensions, and conceptual relationships across the selected literature. Particular attention was given to the relationship between AI-assisted task completion and the cognitive processes involved in generating, evaluating, revising, and internalizing language. Insights from cognitive psychology, SLA, ELT, writing research, creativity studies, and educational technology were integrated to examine how AI-mediated environments may simultaneously support efficiency and create risks of cognitive offloading and reduced generative effort.

This theoretical integration provided the basis for conceptualizing generative struggle as a framework for AI-mediated English language learning and for examining the teacher's role as an epistemic mentor in GenAI-assisted writing. The resulting framework is therefore interpretive and conceptual in nature, intended to organize existing theoretical and empirical insights and to provide propositions for subsequent empirical investigation.

THEMATIC FINDINGS FROM THE LITERATURE SYNTHESIS

Psychological Barriers: Student Insecurity and the Talent Myth

Students' reluctance to engage in independent writing cannot be understood solely in terms of motivation or academic misconduct. The literature indicates that insecurity about writing ability, perceptions of competence, and beliefs about whether writing ability is innate may influence learners' willingness to engage with cognitively demanding writing tasks.

The literature synthesis identified four recurring psychological barriers that may influence ESL learners' engagement with writing, particularly their willingness to undertake new writing tasks using their own cognitive resources. These barriers concern learners' perceptions of their writing ability, their beliefs about competence, their responses to difficulty, and their orientation towards task completion. Figure 1 provides a conceptual representation of these four themes as identified across the synthesised literature.



Overcoming Writing Barriers

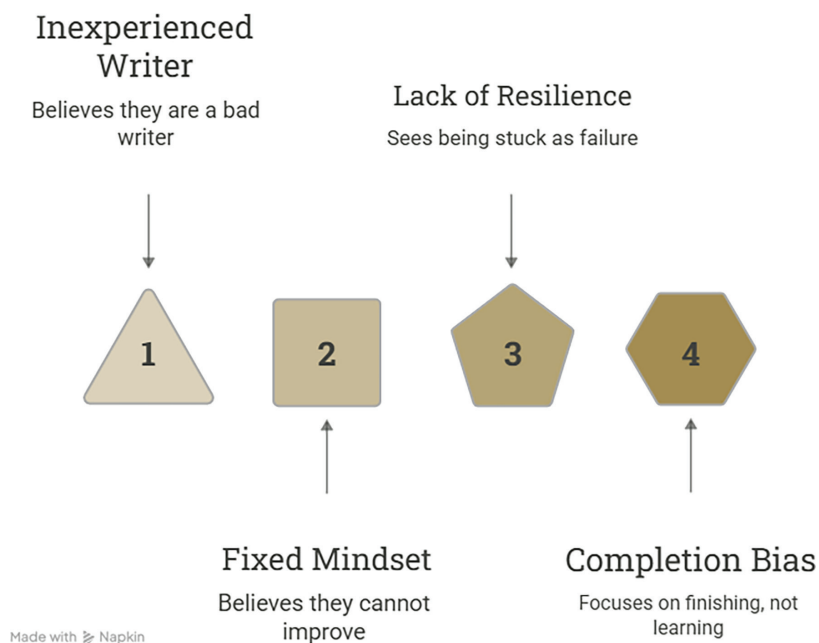


Fig. 1. Psychological Barriers That May Influence ESL Learners' Engagement with Writing.

(Source: Conceptual illustration developed by the authors based on the synthesised literature)

1. The synthesis indicates that learners may interpret difficulties in writing as evidence that they are "bad writers", even when such difficulties may reflect limited experience with writing. Such self-perceptions may undermine confidence and reduce learners' willingness to engage independently with demanding writing tasks.
2. **Fixed Mindset**: The literature suggests that repeated messages concerning limited writing ability may contribute to fixed beliefs about writing competence. Learners who perceive writing ability as relatively stable may be more likely to interpret demanding writing tasks as beyond their capabilities and may consequently seek external assistance before fully engaging with the task themselves.
3. **Metacognitive Resilience**: The synthesis suggests that some learners may turn to external assistance when they encounter difficulty or uncertainty because they have limited resilience in managing the cognitive discomfort associated with being "stuck". From this perspective, difficulty may be interpreted either as evidence of insufficient ability or as part of the learning process. The literature therefore indicates the relevance of helping learners recognise and manage difficulty during cognitively demanding tasks.
4. The literature suggests that an educational emphasis on "finishing" tasks rather than "building competence" may encourage learners to rely on external assistance as a means of reaching the required outcome more efficiently. This orientation may shift attention away from the cognitive processes involved in drafting, revising, and problem-solving towards completion of the final product.



The synthesis also indicates a relationship between learners' perceptions of writing difficulty and their responses to error. Research on error management suggests that errors can provide information about learning processes and opportunities for improvement rather than functioning exclusively as indicators of failure (Keith and Frese, 2008). In SLA, error analysis has likewise examined learners' difficulties in producing written language and developing control over different dimensions of written production. These perspectives provide a basis for understanding error and difficulty as recurring features of the writing process rather than as isolated evidence of limited ability.

Generative struggle as an integrative conceptual construct in cognitive psychology and its relevance to AI-mediated learning

Cognitive psychology suggests that learning is not determined solely by efficient exposure to information but also involves active processes of generation, effort, error, retrieval, and reorganisation. Research on the generation effect, for example, indicates that information actively produced by learners may be remembered more effectively than information that is simply read or received (Slamecka and Graf, 1978; Bertsch et al., 2007). Similarly, research on desirable difficulties indicates that conditions requiring greater cognitive effort can contribute to more durable learning, although their effects depend on the learner, the task, and the learning conditions (Bjork and Bjork, 2011). Within this body of research, the present study uses the term generative struggle as an integrative conceptual construct for examining the role of active cognitive engagement in learning.

The literature synthesis identified five complementary strands that contribute to this conceptualisation: the generation effect, desirable difficulties, writing-to-learn, error-based learning, and cognitive offloading. Each strand addresses a different dimension of cognitive activity involved in learning. The generation effect highlights the role of actively producing information (Slamecka and Graf, 1978; Bertsch et al., 2007); desirable difficulties emphasise the potential learning value of effortful conditions (Bjork and Bjork, 2011); writing-to-learn examines writing as a means of developing and reorganising knowledge (Emig, 1977; Bangert-Drowns et al., 2004; Klein and Boscolo, 2016); error-based learning considers the role of errors in subsequent learning and performance (Keith and Frese, 2008; Metcalfe, 2017); and cognitive offloading examines how cognitive processes can be distributed between internal mental activity and external representations or tools (Risko and Gilbert, 2016).

These established constructs also provide a conceptual basis for interpreting several terms used in the present study. Generative struggle is related to research on generative learning and productive struggle, particularly where learners are required to produce or construct responses through active engagement with a task. Desirable difficulty corresponds to the established principle that certain forms of effortful learning can support subsequent retention and transfer (Bjork and Bjork, 2011). Similarly, writing as thought is situated within the broader literature on writing-to-learn, which examines writing as a learning activity rather than solely as a means of communicating previously acquired knowledge (Emig, 1977; Klein and Boscolo, 2016). The treatment of error as part of the learning process is consistent with research on error management and learning



from errors (Keith and Frese, 2008; Metcalfe, 2017). Finally, concerns about reliance on external cognitive resources are more appropriately situated within the literature on cognitive offloading and automated decision support (Mosier and Skitka, 1996; Risko and Gilbert, 2016).

Taken together, these correspondences position generative struggle within established areas of cognitive and educational psychology rather than presenting it as an entirely separate psychological category. The concept provides an analytical framework for examining the common cognitive processes that emerge across generation, effortful learning, writing, error, and the use of external cognitive resources. In this framework, the relevant issue is not difficulty in isolation but the extent to which learners remain cognitively engaged in generating, organising, evaluating, revising, and reconstructing knowledge.

This conceptualisation also provides a basis for examining learning in AI-mediated environments. GenAI can externalise aspects of information production and text construction, which makes the distinction between internal cognitive activity and external assistance particularly relevant to educational research (Kasneci et al., 2023; Dwivedi et al., 2023; Jose et al., 2025). The framework developed in this study therefore connects established cognitive mechanisms with contemporary questions concerning the distribution of cognitive activity between learners and AI-based systems. This conceptualisation provides a basis for examining how changes in the distribution of cognitive activity may affect learning in technology-mediated environments.

The generation effect and learning as active production

The generation effect refers to the phenomenon whereby information actively produced by learners is remembered more effectively than information that is simply received or read. Slamecka and Graf (1978) demonstrated this effect through a series of experiments in which participants showed higher levels of recall when they generated responses from partial cues than when they read complete responses. Subsequent research has supported the robustness of the generation effect across different learning conditions and domains (Bertsch et al., 2007).

The literature indicates that generation involves more than the passive exposure to information. Actively producing a response requires learners to retrieve, organise, and connect information during the learning process (Slamecka and Graf, 1978; Bertsch et al., 2007). In educational contexts, this suggests that learning can be associated with the cognitive activity required to reconstruct information rather than with exposure alone. For example, generating an individual definition before consulting a standard definition requires the learner to retrieve and organise relevant knowledge before comparing it with externally provided information.

Desirable difficulties and the temporality of cognitive consolidation

The concept of desirable difficulties, discussed by Bjork and Bjork (2011), describes learning conditions that may make performance more demanding in the short term while supporting longer-term retention and transfer. These conditions include spaced practice, retrieval practice, and



variations in learning conditions that require learners to engage actively with the material. Bjork and Bjork (2011) demonstrate that immediate performance is not necessarily a reliable indicator of subsequent learning. Conditions that facilitate short-term performance may not produce equivalent benefits for longer-term retention and transfer, whereas greater effort during learning may contribute to more durable and flexible learning outcomes.

From this perspective, the literature distinguishes between the immediate ease of performing a task and the longer-term consequences of the conditions under which learning takes place. Difficulties may be considered desirable when they require learners to retrieve, reconstruct, or reorganise information rather than simply access it. Effortful learning conditions can therefore create opportunities for learners to engage more actively with the material and to develop knowledge that can be retrieved or transferred beyond the original learning context (Bjork and Bjork, 2011). For example, attempting to solve a problem before consulting a complete solution introduces greater initial difficulty but requires the learner to retrieve relevant knowledge, formulate a response, and subsequently compare that response with the available solution.

The findings on desirable difficulties therefore indicate that learning cannot be evaluated solely through immediate task performance. The temporal dimension of learning is relevant because conditions that increase difficulty during the learning process may be associated with different outcomes over time. In this sense, the literature provides evidence that effort, retrieval, and delayed consolidation can form part of learning conditions that support longer-term retention and transfer (Bjork and Bjork, 2011).

Writing-to-learn and writing as a tool for cognitive reorganization

The body of research known as writing-to-learn examines writing not only as a means of communicating knowledge but also as an activity through which learners can develop and organize their understanding. Emig (1977) conceptualized writing as a mode of learning, while subsequent research has examined the relationship between writing activities and learning outcomes. In a meta-analysis of school-based writing-to-learn interventions, Bangert-Drowns et al. (2004, p. 32) found positive effects of writing activities on academic achievement, particularly when writing required learners to engage with, explain, or reflect on subject matter. Klein and Boscolo (2016, pp. 320–321) further demonstrate that writing can support the organization and transformation of knowledge by requiring learners to formulate, connect, and reconsider ideas during the writing process.

From this perspective, writing involves more than the production of a final textual product. The literature describes writing as a process in which learners formulate ideas, establish relationships between concepts, identify gaps in their understanding, and revise initial formulations (Emig, 1977; Klein and Boscolo, 2016). Writing can therefore provide opportunities for learners to externalize developing ideas and reorganize their understanding through successive stages of composition.

The cognitive demands associated with writing are consequently present throughout the process of composing rather than being restricted to the final product. Formulating an



explanation, for example, requires learners to transform developing or partially formed ideas into explicit linguistic structures and to establish relationships between those ideas. Revision subsequently provides opportunities to reconsider and reformulate initial expressions. Taken together, the literature identifies writing as an activity through which cognitive effort is involved in the development and reorganization of knowledge (Bangert-Drowns et al., 2004; Klein and Boscolo, 2016).

Error-based learning and the epistemic role of error

In contemporary cognitive psychology, error has increasingly been examined as a component of learning rather than solely as an indication of failure. Research on error-based learning and learning from errors considers how discrepancies between expectations and outcomes can provide information for subsequent learning and performance (Keith and Frese, 2008; Metcalfe, 2017). In language education, research on written errors and corrective feedback similarly examines how learners respond to errors during subsequent revision and learning (Hamouda, 2011; Suzuki et al., 2019).

Butterfield and Metcalfe (2001, p. 1493) demonstrated that errors made with a high degree of confidence were more likely to be subsequently corrected, a phenomenon known as the hypercorrection effect. Their findings indicate that the detection of a discrepancy between an initial response and subsequent information can increase attention to corrective information. Metcalfe (2017, p. 468) further examines errors as sources of information that can contribute to changes in knowledge and subsequent performance. From this perspective, error provides information about the relationship between a learner's current understanding and the information or outcome encountered during a task.

In the educational field, Kapur (2008, p. 382) showed through the productive failure model that learners who initially attempted to solve complex problems could subsequently demonstrate stronger conceptual understanding than learners who received complete instruction before attempting the problem. These findings indicate that initial problem-solving attempts can activate prior knowledge and encourage learners to formulate and evaluate possible solutions before receiving formal instruction. Kapur (2016, pp. 289–290) further distinguishes productive failure from unproductive forms of failure and emphasises the role of initial problem-solving attempts in subsequent conceptual learning.

Keith and Frese (2008, p. 66), in a meta-analysis of 24 studies, found that error management training can support learning outcomes when compared with approaches focused primarily on error prevention. Their findings indicate that allowing learners to encounter and manage errors can provide opportunities for reflection, revision, and adaptation. In writing, for example, a learner may formulate a grammatical rule before receiving formal instruction and subsequently revise that formulation in response to feedback or corrective information. Taken together, these findings position error as a component of learning processes through which learners can identify discrepancies, revise existing understanding, and develop more adequate responses.



Cognitive offloading and the externalization of mental processes

Cognitive offloading refers to the use of external resources to reduce or distribute demands on internal cognitive processes, ranging from note-taking and calculators to navigation systems and digital technologies (Risko and Gilbert, 2016, p. 685). Research suggests that reliance on external resources can influence how individuals process and represent information. For example, Barr et al. (2015, pp. 478–479) found that people may use smartphones to reduce the need for internal cognitive processing.

In educational contexts, cognitive offloading is relevant to understanding how learners distribute cognitive activity between internal processes and external resources. Its effects depend on the nature of the task, the information transferred to the external resource, and the extent to which learners remain engaged with the underlying cognitive activity (Risko and Gilbert, 2016). Cognitive offloading can therefore be understood as a redistribution of cognitive activity rather than simply a reduction in cognitive effort.

The synthesis of generative struggle as a transversal learning mechanism

Taken together, the five complementary strands identified in the literature synthesis converge around the role of active cognitive engagement in learning. The generation effect highlights the contribution of producing information; desirable difficulties draw attention to the potential value of effortful learning conditions; writing-to-learn positions writing as an activity through which knowledge can be developed and reorganised; error-based learning considers errors and discrepancies as potential sources of information for subsequent learning; and cognitive offloading examines how cognitive activity can be distributed between learners and external resources (Slamecka and Graf, 1978; Bjork and Bjork, 2011; Emig, 1977; Keith and Frese, 2008; Risko and Gilbert, 2016).

Although the term generative struggle is used in this study as an integrative formulation, its conceptual components are situated within established areas of cognitive and educational psychology. The construct brings together complementary mechanisms examined under different conceptual frameworks, including the generation effect, desirable difficulties, writing-to-learn, error-based learning, and cognitive offloading (Bertsch et al., 2007; Bjork and Bjork, 2011; Klein and Boscolo, 2016; Metcalfe, 2017; Risko and Gilbert, 2016). Rather than proposing these mechanisms as a new psychological category, the study uses generative struggle as an analytical formulation for examining their shared emphasis on active cognitive engagement.

Based on this synthesis, generative struggle can be defined as an integrative conceptual construct describing the cognitive effort involved when learners actively generate, organize, evaluate, revise, and reconstruct knowledge through engagement with difficulty, uncertainty, error, and external representations. The construct brings together processes associated with knowledge construction, retrieval, revision, and reorganizations across the five strands identified in the literature (Slamecka and Graf, 1978; Bjork and Bjork, 2011; Emig, 1977; Keith and Frese, 2008; Risko and Gilbert, 2016). In this study, the construct is used as an analytical framework for examining



the cognitive processes involved in learning when learners engage actively with the task rather than relying exclusively on externally provided solutions.

DISCUSSION

Generative Struggle and Cognitive Engagement

The implications discussed in this study should not be interpreted as a techno- deterministic rejection of educational AI. This concern accompanies recent international debates on GenAI's socio-technical governance and meaningful human oversight in educational and professional settings (Dwivedi et al., 2023; Tlili et al, 2023; Kasneci et al., 2023). On the contrary, the analysis is based on the premise that educational technologies produce different pedagogical effects depending on the curricular structures, evaluative practices and models of human mediation that guide their use. Therefore, the central problem lies not in the presence of AI itself, but in the possibility that educational environments excessively oriented towards efficiency and task completion may reduce opportunities for cognitive elaboration, metacognitive reflection, and generative engagement.

This analysis does not posit that all cognitive offloading is detrimental. When integrated to support, rather than replace, generative processes, educational technology can enhance higher-order reasoning, especially for novices. The challenge is not to eliminate automation, but to ensure it remains a scaffold for active learning rather than a substitute for intellectual autonomy.

From the perspective of CLT, instructional environments should distinguish between cognitive effort that contributes to learning and processing that is unrelated to the construction of knowledge. Excessive emphasis on task completion may encourage learners to allocate cognitive resources to obtaining an answer rather than to the processes required to understand, organise, and apply the underlying information (Sweller et al., 2011).

The conceptual mapping carried out in this research indicates that the mechanisms identified in the synthesis, including the generation effect, desirable difficulties, writing-to-learn, error-based learning, and cognitive offloading correspond to mechanisms widely investigated in educational psychology, and not to merely rhetorical formulations. By drawing on concepts developed in the international literature, the discussion of educational AI can be shifted from a predominantly technological focus towards a cognitive and epistemological framework. Mayer et al.'s (2014) cognitive theory of multimedia learning and Bjork and Bjork's (2011) work on desirable difficulties provide complementary foundations for this perspective.

In general, the constructs analysed converge on the idea that meaningful learning depends on mental effort, active engagement, and metacognitive monitoring. Effort, active engagement, and metacognitive monitoring are central to meaningful learning. Reflective elaboration and problem solving can promote active cognitive processing and knowledge transfer, while productive struggle may create conditions that support deeper learning (Kapur, 2008; Mayer, 2014). Writing as thought and error as a mechanism for learning reinforce this perspective by showing that the active production of responses, even imperfect ones, plays an important role in conceptual reorganization. Both "writing-to-learn" and "error-based learning" indicate that externalizing ideas and confronting



failures favour reflection and the progressive adjustment of mental models (Emig, 1977, pp. 124-125; Metcalfe, 2017, p. 473).

In contrast, the concepts of 'cognitive offloading and automation bias' point to an emerging tension in the context of educational AI. Extensive externalisation of cognitive processes to automated systems may reduce opportunities for active learner participation of the learner, weakening monitoring and self-regulation cycles associated with deep learning (Mosier and Skitka, 1996; Risko and Gilbert, 2016, pp. 682-683).

Furthermore, the main theoretical implication of this study is that the effects of AI in education should be evaluated not only in terms of efficiency, but above all in relation to its impacts on the cognitive mechanisms that underpin learning. Pedagogical automation, when not critically mediated, may displace learners from active elaboration to a position of cognitive dependence. This can directly affect the iterative structure of human learning.

Psychological Barriers, Productive Failure, and Generative Struggle

The psychological barriers identified in the synthesis help explain why learners may avoid the generative effort required for sustained learning. Insecurity about writing ability, perceptions of competence, and difficulties in managing uncertainty may influence learners' willingness to engage with cognitively demanding writing tasks. Raimes (1983) conceptualises writing as closely connected to thinking, suggesting that composing requires learners to develop, organise, and articulate ideas rather than simply reproduce a finished text. From this perspective, difficulties encountered during drafting and revision are not necessarily signs of inadequate ability but may form part of the learning process. Mehdi (2018) further illustrates the challenges learners may encounter in developing control over different dimensions of written language, while Keith and Frese (2008, p. 59) highlight the role of learners' responses to error in learning processes. In AI-assisted writing, immediate reliance on external support may therefore sometimes function as a response to the discomfort associated with writing difficulty, rather than simply as an attempt to avoid effort.

Taken together, these perspectives suggest that insecurity, negative self-perceptions, fixed beliefs about writing ability, limited metacognitive resilience, and a completion-oriented mindset may influence whether learners remain engaged with or withdraw from cognitively demanding writing processes. This is particularly relevant in the context of GenAI, which can provide immediate responses that reduce the uncertainty and difficulty associated with independent writing. When such support replaces rather than supplements learners' own attempts, opportunities for productive struggle may be reduced.

At the same time, this does not imply that GenAI should be excluded from writing instruction. When learners remain actively involved in evaluating, revising, and taking responsibility for AI-assisted outputs, GenAI can serve as a scaffold for critical thinking and language-related decision-making rather than simply as a means of producing a finished text (Umar, 2024; Ulla et al., 2023).

The synthesis also supports the relevance of productive failure as a pedagogical strategy. Kapur (2016) distinguishes productive failure from unproductive forms of failure and demonstrates the value of initial problem-solving attempts for subsequent conceptual learning. In AI-mediated



contexts, immediate access to polished outputs may reduce opportunities for learners to formulate and test their own responses before receiving external assistance. AI-supported task completion may therefore produce successful performance without equivalent gains in understanding, creating a potential “illusion of learning” when completion is mistaken for learning (Kapur, 2016). Sriram (2020) further links productive struggle with myelination, suggesting that repeated practice and feedback strengthen neural pathways and support deeper learning.

This distinction also connects with the historical shift from product-oriented approaches to writing towards more process-oriented perspectives. Anderson’s discussion of current-traditional rhetoric (CTR) highlights a pedagogical tradition that placed considerable emphasis on the formal features and final products of student writing. Such approaches have been criticised for constraining students’ creative engagement with writing, contributing to the development of more process-oriented approaches that foreground the recursive and iterative nature of composing (Anderson, 2010). From the perspective of generative struggle, this shift is particularly relevant because process-oriented writing preserves opportunities for learners to formulate ideas, encounter difficulties, revise their thinking, and develop competence through successive stages of composition.

When instructional design requires learners to engage in cycles of attempts, error, revision, and self-correction, AI can be repositioned not as an automated substitute for thinking, but as a collaborative scaffold within a cognitively active learning process. As illustrated in Kapur’s (2016) instructional design framework, productive success and productive failure both contribute to long-term learning, whereas immediate task completion without cognitive engagement may generate only superficial performance gains (Table 1).

Table 1. Instructional Design (Kapur, 2016, pp. 289-290)

Learning Condition	Short-Term Performance	Long-Term Language Acquisition	Educational Implication
Productive Success	High	High	Learners achieve immediate success while developing durable linguistic competence.
Productive Failure (Generative Struggle)	Low	High	Initial difficulty and cognitive effort foster deeper processing, retention, and transfer of language knowledge. (<i>Proposed Model</i>)
Unproductive Success	High	Low	AI-assisted task completion may create an illusion of mastery without meaningful language development. (<i>Potential Risk</i>)
Unproductive Failure	Low	Low	Neither successful performance nor substantive learning is achieved.

Addressing these behaviours requires more than deterrents; it demands sustained mentorship that supports learners in developing confidence and control as writers. The persistence of difficulties in second-language writing underscores the need for guided pedagogical intervention (Ganai and Naikoo, 2024). From this perspective, addressing AI-assisted writing practices requires pedagogical approaches that maintain learners’ active engagement throughout drafting, revision, error recognition, and self-correction rather than relying primarily on punitive measures or technological restrictions.



The educator as an epistemic mentor

In AI-mediated educational contexts, the role of the educator extends beyond information delivery to the design and mediation of learning processes that preserve learners' active cognitive engagement. When students encounter difficulty, uncertainty, or error during writing, educators can structure activities that require learners to formulate, evaluate, and revise their own responses before consulting AI-generated alternatives. From this perspective, the educator functions as an epistemic mentor by helping learners engage with difficulty and error while guiding the responsible use of GenAI for feedback, comparison, and revision (Kapur, 2016; Metcalfe, 2017).

Rather than prohibiting GenAI, educators can incorporate it into formative activities that require learners to critically examine generated content, identify errors, and justify subsequent revisions. This approach is consistent with Umar's (2024) discussion of AI as a resource for feedback, reflection, revision, and teacher-guided scaffolding in ELT. It also requires attention to cognitive load, as AI-mediated environments may present learners with extensive information and alternative formulations. Effective instructional design should therefore guide learners towards relevant information and require them to process, evaluate, and apply it rather than merely reproduce AIGC (Mayer et al., 2014; Sweller et al., 2011). In this context, the educator mediates between technological affordances and cognitive development, helping ensure that GenAI supports rather than displaces learners' cognitive participation.

Instructional Directions

Instructional directions should also attend to cognitive load management, particularly when AIGC introduce additional information or multimodal elements. Educational psychologists have shown that multimedia presentations containing excessive or redundant information can place unnecessary demands on learners' cognitive processing. In a study of non-native English speakers, Mayer et al. (2014, p. 658) found that redundant on-screen captions did not improve comprehension in narrated English-language video lectures. From this perspective, AI should support evidence-informed instructional methods rather than replace them. By assisting with routine or administrative tasks, AI may allow educators to devote greater attention to pedagogical activities that require human judgement, interaction, and cognitive guidance. The relevant principle is therefore not simply the use of AI, but the design of learning environments in which technological support remains aligned with the processes through which learners develop and demonstrate understanding.

Based on the cognitive and pedagogical implications identified in this study, the following preliminary instructional directions are proposed for the critical and pedagogically responsible integration of AI in ELT and SLA environments (Fig. 2), including:

- Preserve generative activity before AI assistance: learners should be encouraged to formulate their own responses before consulting AI-generated alternatives. Independent drafting, handwritten note-taking, and the use of whiteboards or other external representations can provide opportunities for learners to organise ideas and engage with the material before external assistance is introduced (Kiefer and Velay, 2016). The objective is not to exclude



digital tools, but to preserve opportunities for learners to generate, organise, and externalise their own developing understanding.

- Treat writing as an iterative process: instruction should emphasise concept development as an iterative process rather than privileging polished AIGC. Activities can require learners to formulate initial ideas, revise them, compare alternative formulations, and explain the reasoning behind subsequent changes. In this context, concerns about the nature of AI-generated creativity raised by Runco (2023; 2025) support the need to distinguish between producing a plausible textual output and engaging in the cognitive processes involved in developing and refining ideas.
- Require active evaluation of AI outputs: teachers can position AI as an object of analysis rather than simply as a source of answers. Learners can be asked to examine AI-generated explanations, identify possible inaccuracies or weaknesses, compare alternative responses, and justify whether particular suggestions should be accepted, modified, or rejected. Such activities can support evaluative judgement and epistemic awareness while maintaining cognitive responsibility with the learner.
- Encourage questioning and explanation: learners should be encouraged to formulate questions when they encounter uncertainty or difficulty and to explain the reasoning underlying their responses. Questioning can help make learners' developing understanding more explicit and provide opportunities for teachers to identify misconceptions, gaps in knowledge, and areas requiring further support. Oral explanation can also provide an additional means of assessing whether learners understand the reasoning underlying an AI-assisted response rather than merely reproducing its wording.
- Shift assessment towards reasoning and process: assessment should evaluate not only the final textual product but also the processes through which it was developed. Assignments can therefore require independent drafts, revision histories, error logs, reflective commentary, source verification, and, where appropriate, brief oral explanations or defences. Such designs make learners' reasoning and linguistic decision-making more visible and reduce the extent to which successful task completion alone is treated as evidence of learning.
- Redesign assignments for AI-enabled environments: assignments should be redesigned to reduce opportunities for one-step AI-generated completion and increase opportunities for critique, comparison, revision, and reflection. Rather than asking learners simply to produce a finished text, tasks can require them to document how an initial response was developed, identify changes introduced with AI assistance, evaluate those changes, and justify their final decisions. This approach maintains learner responsibility for the intellectual and linguistic decisions involved in the task.
- Use AI as a dialogic classroom resource: AI can also be incorporated as a discussion partner when its outputs become material for comparison and critical discussion. Learners can examine multiple AI responses, identify differences in reasoning or formulation, and discuss the strengths and limitations of each response. In teacher-guided activities, this use of AI can support critical engagement while keeping interpretation and evaluation with the learner.



- Integrate error analysis and targeted feedback: error analysis can be used diagnostically to identify patterns in learners' developing interlanguage and to inform targeted feedback. In writing instruction, learners can be asked to identify, classify, and explain errors in their own drafts before consulting AI-generated suggestions or teacher feedback. Targeted written corrective feedback can then be incorporated into subsequent revision activities, providing a structured opportunity for learners to recognise linguistic problems, evaluate possible corrections, and apply revised forms (Hamouda, 2011; Suzuki et al., 2019).

AI Integration in ELT and SLA: Pedagogical Strategies

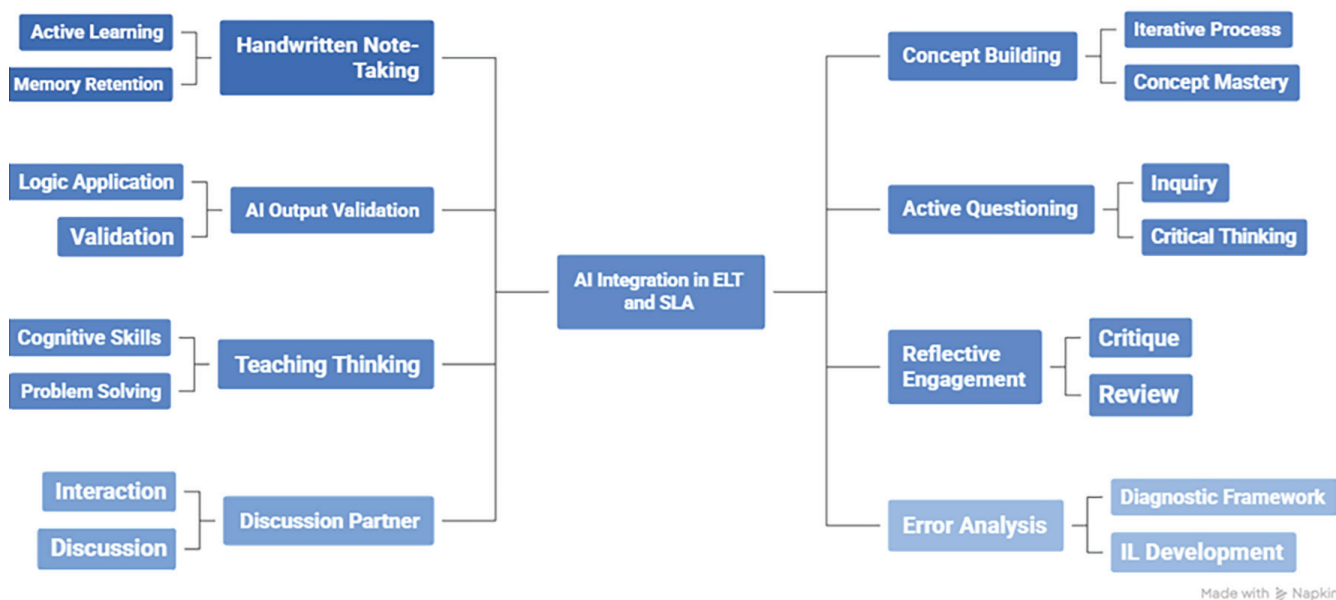


Fig. 2. Instructional Design for AI in educational ELT

(Source: Conceptual illustration developed by the authors based on synthesized literature)

Taken together, these directions position the educator as a mediator between technological affordances and cognitive development across AI-mediated ELT and SLA environments. Within these contexts, AI may be used for feedback, comparison, explanation, and exploratory purposes, while learners remain responsible for generating, evaluating, revising, and justifying their responses. This orientation is consistent with the broader argument of this study that the educational value of AI depends not only on what these systems can produce, but also on the cognitive activity that learners undertake when engaging with them.

To provide greater specificity regarding proficiency levels, educational contexts, and assessment design, these instructional directions for AI integration in ELT and SLA environments are expanded in Table 2.



Table 2. Proficiency- and Context-Sensitive AI Integration

Proficiency / Context	Core AI-Mediated Practices	Assessment Design
A1–A2 (Beginner)	Teacher-mediated AI use; independent drafting; guided error identification.	Unaided draft → guided AI review → oral/written explanation of corrections.
B1–B2 (Intermediate)	Compare drafts with AI suggestions; analyse grammar, vocabulary, and cohesion; justify acceptance/rejection.	Draft comparison, error logs, reflective revision, and process-based assessment.
C1–C2 (Advanced)	Rhetorical experimentation, stylistic comparison, argument development, and critical evaluation of AI outputs.	AI-supported revision, source/citation verification, reflective commentary, and oral defence.
Secondary / Foundational	Teacher guidance, independent drafting, oral explanation, and error analysis.	In-class writing, staged drafts, and brief oral explanations.
Undergraduate / Diploma	Reflective revision, error logs, process portfolios, and source verification.	Process portfolios, peer review, staged submissions, and reflective statements.
Advanced Academic / Professional	Comparative AI evaluation, rhetorical critique, citation verification, and oral defence.	Authentic writing tasks, documented AI use where permitted, critical commentary, and viva-style defence.

Note: AI integration should remain flexible and context-sensitive. Assessment should evaluate not only the polished product but also the learner's reasoning, revision, and linguistic decision-making.

CONCLUSION

This study conceptualizes *generative struggle* as an integrative framework for understanding meaningful learning in AI-mediated English language acquisition. By bringing together the generation effect, desirable difficulties, writing-to-learn, error-based learning, and cognitive offloading, the analysis indicates that learning depends not only on access to information or successful task completion, but also on the extent to which learners remain cognitively engaged in generating, organizing, evaluating, revising, and reconstructing knowledge.

The analysis further suggests that the central educational risk of GenAI is not technological assistance itself, but the displacement of the cognitive processes through which learning develops. When AI-mediated environments prioritize efficiency, polished outputs, and immediate completion, learners may obtain successful products without equivalent engagement in the processes required for understanding, linguistic development, reflection, and transfer. The proposed concept of the *AI education loop* therefore highlights a systemic tension between technological efficiency and the preservation of learner agency and cognitive participation, while the *impressiveness trap* captures the possibility that sophisticated linguistic output may be mistaken for evidence of underlying competence.

Within this framework, productive difficulty, error, revision, and independent generation should not be regarded simply as obstacles to efficient performance. They constitute opportunities through which learners can make their developing knowledge visible, confront uncertainty, reconsider initial formulations, and progressively assume greater control over their linguistic and cognitive processes. AI can contribute to these processes when it is positioned as a resource for comparison, feedback, questioning, and revision rather than as a substitute for the learner's own intellectual activity.



The study consequently repositions the educator as an *epistemic mentor* who mediates between technological affordances and cognitive development. The teacher's contribution lies in designing learning conditions in which learners remain responsible for generating, evaluating, revising, and justifying their responses while using AI selectively and critically. In this sense, responsible AI integration requires not the rejection of automation, but its pedagogical subordination to the cognitive purposes of learning.

The principal contribution of this study is therefore conceptual rather than empirical. *Generative struggle* provides a framework for interpreting AI-mediated language learning through the relationship between cognitive effort, learner agency, error, writing, and external cognitive support. The framework remains open to empirical validation and refinement across proficiency levels, educational settings, and patterns of AI use. Its central proposition is that technological advancement becomes educationally meaningful when it strengthens rather than displaces the cognitive activity through which learners develop reasoning, linguistic autonomy, and intellectual capacity.

LIMITATIONS OF THE STUDY

Several limitations should be acknowledged. First, this study is conceptual and theoretical in nature and does not present original empirical data or experimental validation of the proposed 'generative struggle' framework or the instructional guidelines derived from it. The framework should therefore be regarded as a theory-informed analytical and pedagogical model that remains preliminary and requires empirical validation. Its applicability and effectiveness may vary according to disciplinary knowledge, task structure, learner proficiency, institutional conditions, educational level, and patterns of AI use.

Second, the scope of the literature synthesized in this study is primarily situated within English as a Foreign Language (EFL), ELT, and SLA contexts. Consequently, the conceptual propositions developed here should be extended cautiously to other subjects, language-learning environments, age groups, disciplines, or institutional contexts. Although the cognitive mechanisms discussed may have broader relevance, their pedagogical effects are likely to depend on contextual and disciplinary factors.

Third, although the literature search incorporated indexed databases, including Scopus and ERIC, it also relied on complementary academic dissemination platforms such as Google and ResearchGate. These sources were used to broaden access to relevant and emerging scholarship but may introduce variability in the discoverability, indexing, and quality of available materials. The search strategy should therefore not be considered equivalent to a fully systematic database-based review. In addition, the literature synthesis draws predominantly on English-language scholarship and may consequently underrepresent perspectives from other linguistic and geographical contexts, particularly the Global South and other underrepresented settings. A broader multilingual evidence base may reveal additional perspectives on AI-mediated learning, cognitive engagement, and teacher mediation.

A further limitation is the absence of direct empirical data from students and teachers. Learner perceptions, teacher professional judgements, classroom experiences, institutional constraints,



and patterns of cognitive engagement are therefore interpreted through the existing literature rather than through original interviews, observations, surveys, focus groups, or other forms of primary evidence. Consequently, claims concerning learner behaviour, teacher mediation, and the pedagogical effects of AI remain theoretically grounded rather than directly demonstrated by the present study.

The framework raises psychological dimensions of learners' engagement with generative struggle that were not directly examined empirically. Although the proposed model recognises that student insecurity, self-perceptions of ability, confidence, perceived competence, and beliefs associated with the "talent myth" may influence learners' willingness to engage in cognitively demanding activities, the present study cannot determine how such factors affect responses to difficulty, error correction, AI-generated feedback, or productive struggle. These psychological factors may shape whether learners interpret cognitive difficulty as an opportunity for learning or as evidence of insufficient ability. The framework should therefore not be understood as assuming that all learners will respond to generative struggle in the same way.

Taken together, these limitations indicate that the proposed framework should be interpreted as a theoretically grounded proposition rather than an empirically established model. Future mixed-method, longitudinal, and intervention-based research should test and refine the framework across diverse educational settings, learner proficiency levels, and modes of GenAI-assisted writing. Such research should examine how learners engage with AI-generated feedback and self-correction; whether guided generative struggle enhances linguistic competence, critical thinking, learner autonomy, and metacognitive engagement; how outcomes vary according to levels of AI dependence; and how teachers can function as epistemic mentors while balancing AI assistance with productive cognitive effort. Particular attention should also be given to the interaction between learner beliefs, confidence, perceived competence, responses to difficulty, and the pedagogical conditions under which generative struggle is encouraged. Incorporating learner performance, classroom observation, and student and teacher perspectives would provide the empirical evidence necessary to validate, refine, and extend the proposed framework.

FUTURE RESEARCH

Future research should empirically examine and further refine the generative struggle framework across different educational contexts and patterns of AI-mediated language learning. Experimental studies could compare instruction explicitly designed around generative struggle with conventional AI-assisted instruction, examining differences in learning outcomes, retention, transfer, learner agency, and the quality of linguistic production. Classroom-based action research could further investigate the practical implementation of the instructional guidelines proposed by this framework, particularly by examining how teachers can design AI-mediated activities that preserve productive difficulty, learner responsibility, revision, and cognitive engagement.

Longitudinal studies would also be valuable for determining how sustained exposure to AI-mediated writing assistance influences language development, writing proficiency, autonomy, and patterns of cognitive engagement over time. Finally, intercultural validation is necessary to



determine whether the framework is applicable beyond the Indian and Brazilian contexts considered in the broader discussion and whether cultural, institutional, linguistic, or educational differences shape how generative struggle is experienced and pedagogically implemented. Such research would provide empirical evidence for assessing the explanatory power, practical applicability, and contextual robustness of the framework and could contribute to its further theoretical development.

STATEMENT ON THE USE OF AI

The authors disclose the limited use of an artificial intelligence, based tool for language refinement and editorial assistance. The authors retained full responsibility for the conceptualisation, literature selection, analysis, interpretation, argumentation, and final content, and independently verified all substantive claims and citations.

CONFLICT OF INTEREST STATEMENT

The authors declare that they have no financial, commercial, or personal conflicts of interest related to this study.

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Abbreviations Used in the Article

AI: Artificial Intelligence | AIGC: AI-Generated Content | CLT: Cognitive Load Theory | EFL: English as a Foreign Language | ELL: English Language Learners | ELT: English Language Teaching | GenAI: Generative Artificial Intelligence | LLM: Large Language Models | SLA: Second Language Acquisition