

Critical Thinking Development in GenAI-Supported EFL Argumentative Writing: A Longitudinal Study

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Abstract: *The rapid development of generative artificial intelligence (GenAI) has prompted increasing interest in its pedagogical potential in second language (L2) writing. While prior research has predominantly examined outcomes or learner perceptions, considerably less attention has been paid to the developmental processes through which GenAI mediates critical thinking over time. Conceptualizing GenAI as a human–AI co-regulatory partner, this longitudinal qualitative case study investigates how sustained GenAI-supported interaction shapes critical thinking development in EFL argumentative writing. Drawing on co-regulation theory, metacognitive scaffolding, and cognitive views of critical thinking, the study traces the evolving interactional patterns of four Chinese EFL learners across an eight-week instructional cycle. Data sources include human–AI dialogue transcripts, successive writing drafts, reflective journals, and semi-structured interviews. Integrated longitudinal analysis reveals diverse developmental trajectories influenced by learner beliefs about AI, epistemic orientation, and instructional framing. The findings highlight conditions that enable or constrain co-regulation and offer practical insights for designing AI-mediated writing instruction that fosters critical thinking.*

Keywords: Generative artificial intelligence, Human–AI co-regulation, Critical thinking, Argumentative writing, Longitudinal case study.

1. Introduction

Critical thinking is widely regarded as a core learning outcome of higher education and an essential competence for academic literacy [1][2]. In EFL contexts, it is particularly critical in argumentative writing, where learners must evaluate evidence, anticipate counterarguments, and construct reasoned positions in a second language.

Recent advances in GenAI, especially dialogic large language models, have reshaped instructional practices in L2 writing. Existing studies suggest that GenAI can support idea generation, feedback provision, and revision processes [3][4]. However, much research remains outcome-focused, neglecting the cognitive and interactional processes through which critical thinking develops.

This study addresses this gap by examining GenAI as a co-regulatory partner in a longitudinal qualitative design. Rather than measuring outcomes, it traces how learners' critical thinking evolves through repeated human–AI interaction across four structured argumentative writing tasks. The study focuses on three interconnected research questions:

- 1) How do human–AI interaction patterns unfold longitudinally during GenAI-supported EFL argumentative writing?
- 2) How do learners differ in their trajectories of critical thinking development?
- 3) What learner- and interaction-level factors enable or constrain co-regulation in this context?

These questions are designed to collectively illuminate the process of critical thinking development, account for individual differences, and identify conditions that shape co-regulatory success.

2. Theoretical Framework

2.1 Human–AI Co-Regulation

Co-regulation emphasizes cognition as jointly shaped through interactions with mediating agents, including teachers, peers, and digital tools [5]. In human–AI contexts, GenAI serves as a dialogic partner that can sustain epistemic engagement, promote reflection, and scaffold reasoning, even without intentionality or pedagogical awareness.

2.2 AI-Supported Metacognitive Scaffolding

Scaffolding supports learners beyond their current independent capabilities [6]. In GenAI-mediated learning, scaffolding is realized via iterative, dialogic prompts that encourage evidence evaluation, perspective integration, and reflective revision [7]. Its effectiveness is shaped by learners' interpretation and uptake across repeated interactions.

2.3 Critical Thinking as Cognitive Regulation

Critical thinking is conceptualized as the ability to evaluate claims, reflect on evidence, and revise viewpoints in response to epistemic challenge [8][9]. Development occurs through increasing metacognitive awareness and regulatory control rather than discrete skill acquisition.

3. Research Design and Analytical Framework

3.1 Case Selection Criteria and Rationale

Four focal learners were selected via theoretical and purposeful sampling to capture diverse developmental trajectories [10]. Selection criteria included:

- 1) Initial Critical Thinking Orientation: Diagnosed via a

300-word pre-study essay on “Should social media be banned in schools?” assessed across three dimensions: evidence use, engagement with counterarguments, and epistemic stance, complemented by 4-week classroom observation using a structured checklist.

2) Beliefs About GenAI: Identified through a reflective questionnaire (8 open-ended items) and a 20-minute pilot AI task, categorizing learners as viewing AI as a linguistic tool, authoritative evaluator, or dialogic partner.

3) Early Interaction Behaviors: Contrasting degrees of uptake, resistance, and epistemic negotiation during the pilot AI task, coded on a 3-point scale (low/medium/high).

Table 1: participants’ profiles

Case	Initial Critical Thinking Orientation	Beliefs About GenAI	Early AI Interaction Behavior
A	Open & reflective	Dialogic thinking partner	High uptake, high epistemic negotiation
B	Ideologically committed	Authoritative evaluator	Medium uptake, high resistance
C	Dependent	Authoritative evaluator	High uptake, low epistemic negotiation
D	Instrumental	Linguistic tool	Low uptake of epistemic prompts, focus on form

3.2 Longitudinal Task Design

The study spanned eight weeks, comprising four argumentative writing tasks, each increasing in epistemic complexity. ChatGPT 3.5 was used for AI interaction. Key task design principles:

- 1) Alignment with Epistemic Demand: AI prompts corresponded to specific critical thinking objectives (claim articulation, evidence evaluation, perspective integration, epistemic positioning).
- 2) Explicit Cognitive Guidance: Prompts explicitly encouraged reflection, counterargument consideration, and reasoning justification.
- 3) Iterativeness: Learners engaged repeatedly with AI, allowing observation of developmental change.

Table 2: Task Overview

Task	Topic Focus	Epistemic Demand	AI Role
Task1	Social media & intercultural understanding	Claim articulation	Questioning
Task2	Online learning & educational equity	Evidence evaluation	Counter-argument
Task3	Technology & autonomy	Perspective integration	Reflective prompting
Task4	AI in education	Epistemic positioning	Negotiation

Task Cycle (2 weeks per task):

- 1) Initial Draft: 400–500 words, no AI.
- 2) Structured AI Interaction: 30–40 minutes dialogue with GenAI.
- 3) Revised Draft: 60 minutes average, informed by AI

interaction.

- 4) Reflective Commentary: 150–200 words, documenting reasoning behind accepting/rejecting AI prompts.

This structured cycle ensured comparability across learners and tasks, facilitating longitudinal analysis of epistemic engagement.

3.3 Data Analysis Methods

A three-level coding framework was applied:

Table 3: A Three-level Coding Framework

Level	Dimensions	Categories
1	Interaction Type	AI prompt function: questioning, counter-argument, reflective prompting, negotiation; Learner response: uptake, resistance, negotiation
2	Cognitive Engagement	Surface (form-focused) vs Deep (evidence evaluation/perspective integration); Regulatory actions: planning, monitoring, evaluation, revision
3	Critical Thinking Development	Claim quality (clarity, specificity, rationality); Evidence use (relevance, sufficiency); Counterargument engagement (acknowledgment, response, integration)

4. Longitudinal Case-Based Analysis of Human–AI Co-Regulation

This chapter presents an integrated longitudinal case-based analysis of human–AI co-regulation in GenAI-supported EFL argumentative writing. Four focal learners (Cases A–D) were traced across four writing tasks over eight weeks. Each case is treated as a developmental trajectory, examining how learners’ epistemic engagement, regulatory agency, and orientations toward GenAI evolved through sustained interaction.

Rather than categorizing cases according to predefined types, the analysis foregrounds processes of change over time, highlighting how co-regulation emerged, stabilized, fluctuated, or failed to materialize under different learner and interactional conditions.

4.1 Case A: Progressive Internalization of Epistemic Regulation

Case A entered the study with relatively strong argumentative competence and an explicit belief that GenAI could function as a dialogic thinking partner. In early interactions, however, epistemic engagement remained cautious. During Task 1, when GenAI challenged the learner’s optimistic stance on social media and intercultural understanding, the response acknowledged the challenge while limiting its relevance:

That may occur in some cases, but overall the benefits remain dominant.

This response reflected controlled resistance: the learner recognized the epistemic challenge but avoided restructuring the claim. A qualitative shift became visible during Tasks 2 and 3. Before explicit AI prompting in Task 3, Case A revised the initial draft to incorporate potential counterarguments: *Although social media can increase cross-cultural exposure, without critical awareness users may remain confined to echo chambers.*

Here, epistemic moves that were previously triggered by AI questioning were now self-initiated. GenAI interaction subsequently functioned less as a source of challenge and more as a checkpoint for evaluating balance and coherence. By Task 4, this internalization had stabilized. Case A anticipated likely AI questions and addressed them proactively, using AI primarily to test the robustness of already-refined claims. Reflective and interview data corroborated this shift:

After several tasks, I could almost predict what the AI would question, so I tried to answer those questions myself first.

This trajectory illustrates how sustained exposure to epistemic prompting can lead to the gradual internalization of regulatory strategies, particularly when learners approach GenAI as a collaborative interlocutor rather than an external evaluator.

4.2 Case B: Fluctuating Engagement and Conditional Co-Regulation

Case B exhibited a markedly different developmental pattern, characterized by fluctuating engagement shaped by strong ideological commitment to topic positions. In early tasks, claims were asserted with confidence but supported by limited elaboration. For example, in Task 1, when asked to justify the claim that online education enhances equality, the learner responded:

Access is broader online, so it is more equal.

When GenAI later introduced counter-perspectives related to structural inequality and the digital divide (Task 2), Case B resisted epistemic uptake:

I don't think this applies to my argument because my focus is accessibility.

Rather than prompting reflection, these challenges were perceived as misaligned with the learner's value stance. Interview data revealed that epistemic disagreement was interpreted as ideological confrontation:

When the AI questioned equality, it felt like questioning my values, not just my argument.

As a result, engagement with GenAI prompts became selective. Some challenges were ignored, while others were partially incorporated. By Task 4, limited reconciliation emerged:

Although I value accessibility, the AI's point about digital divides makes me reconsider the universality of my claim.

However, revisions remained additive rather than structurally transformative. This case demonstrates that co-regulation can be disrupted when learners perceive epistemic prompts as threats to personal or ideological commitments, resulting in uneven developmental trajectories.

4.3 Case C: From Epistemic Dependence to Reflective Engagement

Case C began the study with relatively low confidence in argumentative reasoning and initially treated GenAI as an authoritative evaluator. Early interactions reflected epistemic outsourcing. In Task 1, when prompted to consider an opposing perspective, the learner responded:

I changed my idea because the AI's suggestion seemed better.

This pattern persisted until mid-cycle instructional intervention reframed GenAI as a "thinking guide" rather than a judgmental authority. Following this reframing, a gradual shift became evident in reflective journals:

Now I try to explain why I agree or disagree, instead of just following the AI.

Subsequent interactions showed increasing deliberation. In Task 3, Case C articulated reasons before revising claims, using AI prompts as stimuli for comparison rather than directives for compliance. By Task 4, conditional reasoning had become more stable:

The AI raised a good point, but I still think my argument holds because the context here is different.

This trajectory illustrates how GenAI-supported co-regulation can scaffold epistemic confidence over time, provided that pedagogical framing discourages blind acceptance and encourages reflective engagement.

4.4 Case D: Persistent Instrumental Orientation and the Limits of Co-Regulation

In contrast to the other cases, Case D demonstrated minimal developmental change. From the outset, GenAI was treated primarily as a linguistic tool. Across all four tasks, epistemic prompts were redirected toward surface-level concerns:

Can you help me rewrite this sentence more clearly?

Even when prompted to justify claims or evaluate evidence, responses remained descriptive and form-focused. Reflective journals emphasized grammatical accuracy and fluency rather than reasoning processes.

Despite repeated exposure to epistemically rich AI prompts, no substantial shift in interactional pattern or epistemic stance was observed. This case highlights the boundary conditions of human-AI co-regulation: dialogic affordances alone are insufficient to foster critical thinking development without learner willingness to engage epistemically.

4.5 Cross-Case Synthesis

Across the four cases, human-AI co-regulation unfolded along a continuum of developmental trajectories.

These trajectories demonstrate that GenAI does not function as a uniform scaffold. Instead, co-regulation is dynamically shaped by learners' epistemic orientations, beliefs about AI, and interpretive stances toward epistemic challenge. Learners who construed GenAI as a dialogic partner were more likely to appropriate and internalize regulatory strategies, whereas

authoritative or instrumental conceptions constrained epistemic engagement.

Table 4: Cross-Case Patterns

Case	Initial Orientation	Interaction Pattern	Developmental Trajectory
A	Dialogic partner	High epistemic negotiation	Internalization of regulatory strategies
B	Ideologically committed	Selective uptake/resistance	Uneven development, partial reconciliation
C	Epistemic dependence	From blind acceptance to critical reflection	Reflective engagement
D	Instrumental	Low epistemic engagement	No significant development

5. Discussion

This study examined how human–AI co-regulation unfolds longitudinally in GenAI-supported EFL argumentative writing, how learners differ in their developmental trajectories, and which conditions enable or constrain the co-regulatory support of critical thinking. Drawing on detailed case-based analysis, several key insights emerge.

5.1 Human–AI Co-Regulation as a Developmental Process

Findings indicate that co-regulation in AI-mediated writing is not an immediate outcome of AI availability but a developmental process that unfolds through repeated interaction. Early AI prompts often functioned as external cues, eliciting surface-level responses. Over time, some learners appropriated these prompts as internalized strategies for anticipating counterarguments, evaluating evidence, and regulating argument structure.

This progression aligns with sociocultural accounts of regulation as distributed and gradually internalized [11]. GenAI operated as a temporary externalization of epistemic control, which, under conducive conditions, was progressively transferred to the learner.

5.2 Individual Differences and Epistemic Orientation

A central finding concerns the role of learner beliefs about AI. Learners who approached GenAI as a dialogic partner (Case A) demonstrated sustained epistemic engagement and internalization of regulatory strategies. In contrast, authoritative or instrumental orientations either led to epistemic outsourcing (Case C initially) or limited engagement (Case D).

Importantly, learner beliefs were not static. Instructional framing played a crucial role in reshaping epistemic orientation, as seen in Case C's transition from dependence to reflective engagement. This finding extends existing research by highlighting belief malleability as a key mechanism in AI-supported learning.

5.3 Enabling and Constraining Conditions for Co-Regulation

Three enabling conditions emerged:

1) Dialogic framing of AI as a thinking partner rather than an

evaluator.

2) Epistemically rich prompts targeting evidence evaluation and perspective integration.

3) Longitudinal exposure, allowing learners to reinterpret and appropriate AI feedback over time.

Conversely, co-regulation was constrained by:

1) Ideological resistance, where epistemic challenges were perceived as value threats (Case B).

2) Instrumental orientations, which redirected interaction toward surface-level concerns (Case D).

These findings suggest that the pedagogical effectiveness of GenAI depends less on its technical sophistication than on how learners are guided to interpret and engage with its epistemic affordances.

6. Conclusion

This study provides a longitudinal, case-based account of human–AI co-regulation in EFL argumentative writing, highlighting the interplay of learner beliefs, epistemic engagement, and AI-mediated interaction. Overall, this research underscores that the pedagogical value of GenAI lies not merely in technical features, but in learners' interpretation, appropriation, and guided use of AI prompts over time. It contributes to theory by extending co-regulation frameworks to human–AI contexts and informs practice by providing actionable guidance for task design, AI prompt engineering, and learner support strategies.

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