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AI as a Metacognitive Mirror: How Students Use AI to Monitor and Repair Reading Comprehension Breakdowns

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Abstract: The increasing availability of artificial intelligence (AI) tools has transformed how EFL students engage with academic reading, yet little is known about how AI shapes learners' metacognitive processes during reading. This qualitative study conceptualizes AI as a metacognitive mirror and investigates how EFL students use AI to monitor and repair reading comprehension breakdowns. Data were collected from undergraduate EFL students at a public university through academic reading tasks, screen recordings, think-aloud protocols, AI interaction logs, and stimulated recall interviews. Thematic analysis revealed that students used AI to externalize comprehension monitoring by confirming interpretations and articulating sources of confusion. AI also supported comprehension repair through strategy-specific and iterative regulation, enabling learners to request paraphrases, examples, and simplified explanations in response to perceived difficulties. However, the findings also indicate tensions between productive metacognitive support and uncritical reliance on AI, particularly when learners accepted AI-generated explanations without verification. The study contributes to AI-assisted reading research by shifting attention from learning outcomes to metacognitive processes and learner agency. Pedagogical implications highlight the importance of guiding students toward reflective and responsible AI use to support academic reading comprehension.

Keywords: artificial intelligence, EFL reading, learner agency, metacognition, self-regulated learning

INTRODUCTION

The rapid integration of artificial intelligence (AI) tools into educational contexts has significantly reshaped how students engage with texts, particularly in English as a Foreign Language (EFL) learning environments. AI-powered tools such as large language models, intelligent tutoring systems, and automated explanation generators are increasingly used by students to support reading comprehension, offering features such as summarization, paraphrasing, vocabulary explanation, and question answering (Hsiao & Chang, 2023; Qassrawi & Al Karasneh, 2025; Srinivasan & Murthy, 2021). While a growing body of research has examined the effectiveness of AI in improving reading outcomes, far less

attention has been paid to how students actually use AI during the reading process and how such use shapes their metacognitive engagement with texts.

Reading comprehension is not merely a cognitive activity but a metacognitive one, requiring learners to monitor their understanding, recognize comprehension breakdowns, and deploy appropriate strategies to repair meaning (Andersen et al., 2022; Aziz & Rawian, 2022; Peng et al., 2024). In EFL contexts, these demands are intensified by linguistic complexity, unfamiliar discourse structures, and limited background knowledge. Students often struggle not because they lack decoding ability, but because they fail to notice when comprehension breaks down or do not know how to address such difficulties strategically (Ortiz-Gómez et al., 2025; Tarchi & Casado Ledesma, 2024). Consequently, metacognitive awareness and regulation have long been recognized as central to successful reading comprehension.

Traditional research on metacognition in reading has emphasized learners' ability to plan, monitor, and evaluate their comprehension through strategies such as self-questioning, summarizing, rereading, and using contextual clues. However, the emergence of AI tools introduces a new mediational layer into this process. Rather than relying solely on internal strategies or teacher feedback, students can now externalize their comprehension checks by consulting AI tools in real time (Shafiee Rad, 2025; Wangdi & Shimray, 2025; Yuan, 2025). This development raises important questions about how AI reshapes metacognitive practices, particularly whether it supports or undermines learners' ability to monitor and regulate their own understanding.

Existing studies on AI-assisted reading in EFL settings have largely focused on measurable learning gains, comparing test scores between AI-supported and non-AI-supported groups (Alazemi, 2024; Alshakhi, 2025; Wang, 2025). While such studies provide valuable evidence of effectiveness, they often treat AI as a uniform intervention and overlook the variability in how students engage with it. This outcome-oriented approach risks obscuring the complex processes through which AI mediates reading comprehension, including moments of uncertainty, decision-making, and strategic adjustment. As a result, there is a growing call for process-oriented research that examines learners' interactions with AI in situ, especially during cognitively demanding tasks such as academic reading.

One underexplored dimension of AI-assisted reading is its potential role in metacognitive monitoring. When students ask AI to summarize a paragraph, confirm their interpretation, or explain a confusing sentence, they are not only seeking information but also engaging in a form of self-checking (Khojasteh et al., 2025; Thongsan & Anderson, 2025). In this sense, AI can function as a "metacognitive mirror" that reflects learners' understanding back to them, making comprehension more visible and explicit. Through interaction with AI, learners may become more aware of what they understand, what they misunderstand, and what requires further attention (Yin et al., 2025; Xu et al., 2024; Yang & Xia, 2023). However, the extent to which students consciously use AI for monitoring purposes, rather than as a shortcut to answers, remains insufficiently examined.

Equally important is how students use AI to repair comprehension breakdowns once they are identified (Thüs et al., 2024). Comprehension breakdowns may arise from lexical difficulty, syntactic complexity, dense information, or lack of background knowledge. In traditional reading instruction, learners are encouraged to deploy repair strategies such as rereading, slowing down, using reference materials, or seeking clarification from peers or teachers (Habók et al., 2024; Hassan et al., 2025). With AI, students can request paraphrases, examples, simplified explanations, or conceptual links across text segments (Nguyen et al., 2024). These actions potentially represent a new form of strategy regulation, where learners coordinate their reading behavior in response to AI-generated feedback. Yet, it is unclear whether such practices enhance learners' strategic repertoire or foster dependence on external assistance.

Another critical issue concerns learner agency and self-regulation in AI-mediated reading. The presence of AI does not automatically lead to effective metacognitive engagement. Students must decide when to consult AI, how to phrase their prompts, and how to interpret and evaluate the responses they receive (Liu & Wang, 2024). These decisions reflect learners' beliefs about reading, their confidence in their own understanding, and their epistemic trust in AI-generated explanations. Some learners may use AI selectively to confirm understanding, while others may defer prematurely to AI, bypassing opportunities for productive struggle (Canonigo, 2024; Fan et al., 2025). Understanding these variations is essential for developing pedagogically responsible approaches to AI integration.

Despite increasing interest in AI literacy and responsible AI use in education, empirical research that captures learners' real-time metacognitive interactions with AI during reading remains limited (Lin et al., 2025). Much of the existing literature relies on self-report surveys or post-task interviews, which may not fully capture the dynamic nature of comprehension monitoring and repair. There is a need for studies that examine how students interact with AI moment by moment, particularly at points where comprehension falters and strategic decisions are required.

In EFL higher education contexts, this gap is especially significant. University students are frequently required to engage with complex academic texts in English, often with limited instructional support. AI tools are increasingly used independently by students outside the classroom, making their practices largely invisible to teachers (Buele et al., 2025). Investigating how EFL students use AI to monitor and repair reading comprehension breakdowns can therefore provide valuable insights into both learner behavior and pedagogical implications. Such insights can inform instructional design, helping educators guide students toward metacognitively productive uses of AI rather than uncritical reliance.

Against this backdrop, the present study conceptualizes AI as a metacognitive mirror that mediates students' awareness and regulation of reading comprehension. Rather than evaluating whether AI improves reading performance, this study focuses on how students use AI to (1) monitor their understanding and identify comprehension breakdowns and (2) repair comprehension difficulties and regulate their reading strategies. By adopting a

qualitative, process-oriented approach, the study seeks to illuminate the metacognitive functions that AI serves during academic reading tasks and the ways learners exercise agency in AI-mediated environments. Specifically, the study is guided by the following research questions:

1. How do EFL students use AI tools to monitor their understanding and identify reading comprehension breakdowns while engaging with academic texts?
2. How do EFL students use AI-generated responses to repair comprehension difficulties and regulate their reading strategies?

By addressing these questions, the study aims to contribute to a deeper theoretical understanding of metacognition, self-regulated learning, and AI mediation in EFL reading. It also seeks to offer practical insights for educators and researchers interested in fostering critical, strategic, and responsible AI use in language learning contexts.

LITERATURE REVIEW

Analytical Lens

This study is analytically grounded in theories of metacognition, self-regulated learning, and mediated cognition, which together provide a robust framework for understanding how EFL students use AI during reading comprehension. At its core, reading comprehension is a strategic and reflective process that requires learners to actively monitor their understanding, evaluate meaning construction, and regulate strategies when comprehension difficulties arise (Ruffini et al., 2025). Metacognition, commonly defined as knowledge about one's cognitive processes and the regulation of those processes, is therefore central to successful reading (Ghimire & Mokhtari, 2025; Juhkam et al., 2023).

Within reading research, metacognition is often conceptualized through two interrelated components, namely metacognitive knowledge and metacognitive regulation. Metacognitive regulation encompasses monitoring, control, and evaluation. Monitoring refers to learners' awareness of their current level of understanding, control involves decisions about strategy use, and evaluation concerns judgments about the effectiveness of those strategies (Mustopa et al., 2024; Tibken & Tiffin-Richards, 2025; Wang et al., 2023). In EFL reading contexts, learners frequently struggle with monitoring comprehension accurately, which can result in either unrecognized misunderstanding or unnecessary reliance on external support (Allehyani, 2025). This study focuses particularly on monitoring and repair as observable manifestations of metacognitive regulation during reading.

Self-regulated learning theory further extends this perspective by emphasizing learners' active role in managing their learning processes. Self-regulated readers set goals, deploy strategies, monitor progress, and reflect on outcomes (Chang et al., 2023; T. Wang et al., 2023). Importantly, self-regulation is not an entirely internal process but is shaped by available tools, contextual affordances, and learners' beliefs. In AI-mediated reading environments, AI tools become part of the regulatory system, influencing how learners plan, monitor, and adjust their reading strategies (Jin et al., 2023; Wolters et al., 2023).

From this perspective, students' decisions to consult AI, the timing of such consultation, and their interpretation of AI-generated responses reflect varying degrees of learner agency and self-regulatory competence (Fitriati & Williyani, 2025).

To account for the role of AI in shaping metacognitive activity, this study also draws on sociocultural and mediated cognition perspectives (Wheaton et al., 2024). These perspectives view learning as mediated by cultural tools that shape cognitive activity rather than merely supporting it. AI tools, particularly those capable of generating explanations and feedback, function as mediational artifacts that externalize cognitive and metacognitive processes (Iqbal et al., 2025; Yang & Xia, 2023). By prompting learners to articulate confusion, test interpretations, or request clarification, AI can make otherwise implicit metacognitive processes visible and negotiable. This mediational role underpins the concept of AI as a "metacognitive mirror," reflecting learners' understanding back to them and enabling heightened awareness of comprehension states.

To clarify the analytic scope of this metaphor, this study defines "AI as a metacognitive mirror" in a restricted and operational sense. AI use is considered metacognitive mirroring only when learners engage in monitoring, control, or evaluation of their comprehension as a result of interacting with AI. This includes instances where learners explicitly assess whether they understand a text, diagnose sources of confusion, or regulate reading strategies based on AI-generated feedback. In contrast, AI use that merely supplies information, such as providing definitions, paraphrases, or summaries without evidence of learner evaluation or strategic decision-making, is treated as cognitive assistance rather than metacognitive mirroring. Analytically, AI interactions were therefore coded as metacognitive mirroring only when they were embedded in observable cycles of comprehension monitoring, strategy adjustment, or evaluative judgment, rather than as standalone information-seeking acts.

At the same time, mediated cognition theory cautions against assuming that tools automatically lead to higher-order regulation (Reinhold et al., 2024). The quality of mediation depends on how learners appropriate the tool and the purposes for which it is used (Xu et al., 2025). AI may support metacognitive monitoring when learners use it to confirm or question their understanding (Raitskaya & Tikhonova, 2025), but it may also reduce metacognitive effort if learners defer prematurely to AI-generated interpretations (Fan et al., 2025). Therefore, this analytical lens emphasizes the interaction between learner agency and technological affordances, rather than attributing outcomes solely to the presence of AI.

Metacognition, self-regulated learning, and mediated cognition provide a coherent framework for examining AI-assisted reading as a dynamic process. This framework allows the present study to investigate not only what students do with AI, but how and why they do so at moments of comprehension difficulty. It also foregrounds the importance of learners' strategic decision-making and reflective engagement, which are central to the study's research question.

Previous Studies

Research on reading comprehension in EFL contexts has long highlighted the importance of metacognitive strategies such as self-questioning, summarizing, inferencing, and monitoring comprehension (Momdjian & Chidiac, 2024; Noipa & Phusawisot, 2024). Studies consistently show that learners who actively monitor their understanding and employ repair strategies achieve higher levels of comprehension than those who read passively (Ghimire & Mokhtari, 2025; Muche et al., 2024). However, many EFL learners, particularly at the tertiary level, demonstrate limited metacognitive awareness and struggle to identify comprehension breakdowns independently (Alfahad, 2025; Anggia & Habók, 2023). This challenge has prompted interest in instructional and technological supports that can scaffold metacognitive engagement.

With the rise of educational technologies, digital tools have increasingly been used to support reading comprehension. Early studies examined hypertext glosses, online dictionaries, and multimedia annotations, finding that such tools can facilitate vocabulary learning and local comprehension (Rohollahzadeh Ebadi, 2025; Udry & Berthele, 2025; Zhu et al., 2024). More recent research has shifted toward AI-powered tools, including intelligent tutoring systems and large language models, which offer more flexible and interactive forms of support (Benvenuti et al., 2023; Brod, 2024). These tools can generate explanations, summaries, and answers to learner-generated questions, making them particularly attractive for independent reading.

Despite this growing interest, much of the literature on AI-assisted reading remains outcome-focused. Numerous studies compare reading comprehension scores between students who use AI tools and those who do not, often reporting positive effects (McCarthy & Yan, 2024; Wei, 2023). While these findings suggest that AI can be beneficial, they provide limited insight into the underlying processes through which AI influences comprehension. As a result, it remains unclear whether improved performance reflects deeper understanding, improved strategy use, or surface-level dependence on AI-generated explanations.

A smaller but growing body of research has begun to examine learners' interactions with AI more closely. Some studies have analyzed students' prompts and chat logs, revealing wide variation in how learners engage with AI (Güner & Er, 2025; Kim et al., 2025). For example, higher-performing learners tend to ask clarification and confirmation questions, while lower-performing learners are more likely to request direct answers or summaries. These findings suggest that AI use is closely tied to learners' metacognitive awareness and strategic competence (Yang & Xia, 2023). However, such studies often focus on writing tasks or problem-solving contexts, with relatively limited attention to reading comprehension.

Research explicitly addressing metacognition in AI-assisted reading is still emerging. A few studies indicate that AI can support comprehension monitoring by providing immediate feedback and alternative explanations (Lee & Moore, 2024; Shafiee Rad, 2025). Learners report using AI to check whether their interpretation is correct or to identify which parts of a text they do not understand. However, these insights are typically

derived from self-report questionnaires or interviews conducted after task completion. Such methods may not fully capture the moment-to-moment processes of monitoring and repair that occur during reading.

Another strand of research has raised concerns about overreliance on AI and its potential impact on learner autonomy. Some studies suggest that frequent AI use may reduce learners' willingness to engage in effortful reading strategies, particularly when AI provides fluent and authoritative explanations (Essien et al., 2024; Fan et al., 2025). This concern is closely related to issues of epistemic trust and metacognitive control. When learners accept AI responses uncritically, monitoring and evaluation processes may be diminished. These findings underscore the need to examine not only whether learners use AI, but how they evaluate and regulate its use in relation to their own comprehension.

In EFL higher education contexts, research on students' informal and independent use of AI for reading remains particularly limited. Many studies focus on classroom-based interventions, overlooking the fact that students often use AI outside institutional settings to cope with academic reading demands. This gap is significant, as out-of-class AI use may shape learners' reading habits and metacognitive development in ways that are invisible to teachers. Understanding these practices requires qualitative, process-oriented methodologies that can capture learners' real-time interactions with AI.

Existing research points to the potential of AI to support reading comprehension, while also highlighting unresolved questions about metacognitive engagement, learner agency, and strategic regulation. There is a clear need for studies that move beyond performance outcomes to examine how learners use AI to monitor and repair comprehension breakdowns as they occur. By focusing on these processes, the present study seeks to extend previous research and contribute a nuanced understanding of AI as a metacognitive mediator in EFL reading contexts.

However, even existing qualitative and interaction-focused studies on AI-assisted learning remain limited in important ways. Prior research has tended to analyze prompts, chat logs, or retrospective interviews without systematically tracing the temporal sequencing of comprehension monitoring and repair as it unfolds during reading. Moreover, much of this work focuses on writing or problem-solving tasks rather than extended academic reading, where comprehension breakdowns emerge incrementally and require ongoing regulation. As a result, we still lack fine-grained, moment-by-moment accounts of how learners diagnose breakdowns, decide to consult AI, and regulate their strategies in response to AI-generated feedback while reading. Addressing this gap, the present study uniquely captures real-time metacognitive regulation during academic reading by integrating screen recordings, think-alouds, AI interaction logs, and stimulated recall interviews, thereby illuminating how AI functions as a metacognitive mirror in situ rather than through retrospective or outcome-based lenses.

METHODS

Research Design

This study adopted a qualitative, process-oriented research design to explore how EFL students use AI tools to monitor and repair reading comprehension breakdowns while engaging with academic texts (Crompton et al., 2024). Rather than examining learning outcomes or causal effects, the design focused on capturing learners' real-time interactions with AI and their metacognitive decision-making during reading. This approach is appropriate given the study's emphasis on metacognitive processes, learner agency, and strategy regulation, which are not easily observable through quantitative measures alone.

A task-based qualitative design was employed, in which participants completed an academic reading task while having access to an AI tool of their choice (Lai, 2024; Mulyadi et al., 2023). The reading task was designed to simulate authentic university-level reading demands, requiring students to engage with a dense expository text relevant to their field of study. By embedding AI use within a meaningful reading activity, the study aimed to capture naturalistic patterns of monitoring and repair as comprehension challenges emerged. Although participants used different AI tools, the study did not aim to compare tools or evaluate their technical features. Instead, variability in AI systems was analytically bracketed, and the unit of analysis focused on learners' actions, prompts, and regulatory decisions when interacting with AI, rather than on the affordances of specific tools. This approach allowed the analysis to foreground metacognitive processes that cut across different AI platforms.

To gain insight into both observable behavior and learners' reflective reasoning, the study integrated multiple qualitative data sources, including screen recordings, AI interaction logs, think-aloud protocols, and stimulated recall interviews. This methodological triangulation enhanced the credibility and depth of analysis by allowing cross-validation of findings across different data types. The design was guided by an interpretive paradigm, recognizing that learners' use of AI is shaped by subjective meanings, beliefs, and contextual factors.

Participants

The participants were undergraduate EFL students enrolled at a public university. A purposive sampling strategy was used to select participants who met three criteria. First, participants had to be non-native speakers of English who used English primarily in academic settings. Second, they had to have prior experience using AI tools for academic purposes, particularly for reading or studying. Third, they were required to be currently enrolled in courses that involved regular engagement with English academic texts.

A total of 18 students participated in the study. This number was considered sufficient for in-depth qualitative analysis while allowing for variation in AI use practices and reading strategies. The participants represented diverse academic majors, including education, social sciences, and applied linguistics, which ensured exposure to different types of

academic texts. Their English proficiency ranged from lower-intermediate to advanced, as indicated by institutional placement records and self-reports.

Prior to data collection, all participants provided informed consent. They were informed that their participation was voluntary, that they could withdraw at any time, and that all data would be anonymized. Ethical approval was obtained from the university's research ethics committee. To protect participants' privacy, pseudonyms were used in all transcripts and reports, and no identifying information was included in the presentation of findings.

Data Collection

Data collection took place over a four-week period and consisted of four main stages. In the first stage, participants completed a background questionnaire designed to gather information about their English learning history, prior experience with AI tools, and general reading habits. This information was used to contextualize participants' AI use and reading strategies during analysis.

In the second stage, participants were asked to complete an individual academic reading task. Each participant read a selected English academic text of approximately 1,200 to 1,500 words. The texts were chosen to be moderately challenging, containing complex syntax and discipline-specific vocabulary, while remaining accessible to participants' proficiency levels. During the task, participants were allowed to use any AI tool they normally used for academic reading. No specific instructions were given regarding when or how to use AI, in order to preserve naturalistic behavior.

While completing the reading task, participants' screens were recorded using screen capture software. The recordings captured scrolling behaviour, pauses, highlighting, AI consultations, and prompt formulation. Participants were also asked to verbalize their thoughts using a think-aloud protocol, particularly when they encountered difficulty or decided to consult AI. The think-alouds were audio-recorded and later transcribed verbatim. To minimize disruption to natural reading, think-aloud prompts were used sparingly and only when participants paused for an extended period or initiated AI use. Prompts were non-directive in nature, such as "Please say what you are thinking right now" or "What is going through your mind at this point," and participants were not required to verbalize continuously throughout the task.

In the third stage, AI interaction logs were collected. These logs included participants' prompts, follow-up questions, and AI-generated responses during the reading task. The logs provided direct evidence of how participants articulated comprehension problems, monitored understanding, and sought repair through AI. Together with the screen recordings, the logs allowed for detailed reconstruction of reading episodes involving comprehension breakdowns.

In the final stage, stimulated recall interviews were conducted within 48 hours of the reading task. During the interviews, participants were shown selected excerpts from their screen recordings and AI interactions. They were asked to explain what they were

thinking at specific moments, why they decided to consult AI, and how they interpreted the AI's responses. The interviews lasted approximately 30 to 45 minutes and were audio-recorded and transcribed. This stage was critical for accessing participants' metacognitive reasoning that may not have been fully articulated during the think-alouds.

Data Analysis

Data analysis followed a thematic analysis approach, informed by the study's analytical lens and research questions (Roseveare, 2023). Analysis began with data familiarization, during which all transcripts, screen recordings, and AI logs were reviewed multiple times. The researcher created detailed analytic memos to document initial observations, recurring patterns, and notable moments of comprehension monitoring and repair.

In the first coding phase, open coding was conducted across all data sources. Segments of data were coded for instances of comprehension monitoring, breakdown identification, AI consultation, and strategy use. Codes captured both actions, such as requesting a summary or paraphrase, and reflective statements, such as expressing uncertainty or confidence. AI prompts were treated as metacognitive artifacts, providing insight into how learners externalized their comprehension checks.

In the second phase, codes were grouped into broader categories through axial coding. These categories included types of monitoring behaviors, forms of breakdown diagnosis, AI-mediated repair strategies, and patterns of strategy regulation. Particular attention was paid to the sequencing of actions, such as what prompted AI use and how learners responded after receiving AI feedback. This process allowed the researcher to trace metacognitive cycles within and across participants.

In the final phase, themes were developed that captured recurring patterns of AI use as a metacognitive mirror. Themes were refined through constant comparison across participants and data sources to ensure internal coherence and analytic depth. Negative cases and variations were actively sought to avoid overgeneralization. To enhance trustworthiness, approximately one-third of the data corpus was independently coded by a second researcher with expertise in qualitative analysis and EFL learning. Coding discrepancies were discussed through iterative meetings until analytic consensus was reached, and the agreed-upon coding framework was then applied to the remaining data.

Although the study did not aim to compare participants by proficiency level or confidence systematically, analytic attention was paid to variation across cases. Patterns emerging from cross-case comparison suggested that learners who demonstrated stronger self-regulatory confidence tended to use AI for confirmation, evaluation, and reflective monitoring, whereas others engaged in more retrospective or answer-oriented AI use. These observations are presented as interpretive patterns rather than categorical claims, intended to illuminate the range of AI-mediated metacognitive engagement observed in the data rather than to establish subgroup differences.

Throughout the analysis, reflexivity was maintained by acknowledging the researcher's role in interpretation and by grounding claims in rich, representative excerpts. The

integration of multiple data sources enabled triangulation, strengthening the credibility of the findings. The analysis ultimately aimed to illuminate how EFL students monitor and repair reading comprehension breakdowns through AI-mediated interaction, in direct response to the study's research questions.

FINDINGS

This section presents the findings of the study, organized according to the two research questions. The analysis reveals how AI functioned as a metacognitive mirror, enabling students to externalize, inspect, and regulate their reading comprehension processes. Rather than using AI merely to obtain meanings or summaries, participants engaged with AI in ways that reflected varying levels of metacognitive awareness, strategic control, and agency. Across both research questions, monitoring and repair emerged not as isolated behaviours but as interconnected phases of a recursive metacognitive cycle, in which awareness of understanding prompted regulation, and regulatory actions reshaped subsequent monitoring.

RQ1 Findings: AI Use for Monitoring Understanding and Identifying Comprehension Breakdowns

Analysis of screen recordings, think-alouds, AI interaction logs, and interviews revealed that participants used AI primarily as a tool for monitoring their understanding and identifying comprehension breakdowns. Three interrelated themes emerged, namely confirmation-based monitoring, articulation of uncertainty, and delayed recognition of breakdowns. Collectively, these themes illustrate variation in learners' metacognitive monitoring, defined as their ability to assess the adequacy of comprehension during reading.

Confirmation-Based Monitoring

A common pattern across participants was the use of AI to confirm existing interpretations rather than to replace reading. Participants frequently consulted AI after reading a paragraph or section to check whether their understanding was accurate. This behavior reflected an awareness that comprehension is fallible and requires verification. Typical prompts included requests such as "Is my understanding correct?" or "Can you check if this paragraph means what I think it means?" One participant explained during a stimulated recall interview:

"I felt I understood it, but I was not fully confident. So I asked the AI to explain it and then I compared it with my understanding."

This form of confirmation-based monitoring positioned AI as a reflective surface through which learners could inspect their comprehension. Rather than signaling confusion, AI use in these instances marked a strategic pause in reading, where learners actively evaluated their cognitive state. Screen recordings showed that participants often returned to the original text after receiving AI feedback, suggesting that AI did not replace engagement with the text but supported metacognitive evaluation. This pattern was observed across the majority of participants, indicating that confirmation-based monitoring constituted a dominant mode of AI use in this dataset.

Articulation of Uncertainty Through AI Prompts

A second theme concerned how AI enabled participants to articulate uncertainty that might otherwise remain implicit. During think-aloud sessions, several participants struggled to verbalize what exactly they did not understand until they began formulating AI prompts. The act of writing prompts required learners to specify whether their difficulty was lexical, syntactic, or conceptual.

For example, one participant initially stated, “This paragraph is confusing,” but then refined the prompt to ask, “Why does the author connect these two ideas about policy and identity?” This shift from vague confusion to targeted questioning indicated an emerging metacognitive awareness. As one participant noted:

“When I write the question to AI, I realize what part is actually confusing. Before that, I just feel lost.”

In this way, AI prompts functioned as metacognitive scaffolds that supported the diagnosis of comprehension breakdowns. The findings suggest that the process of interacting with AI can itself prompt reflection, independent of the AI’s response. Although this behaviour was not observed in every case, it appeared repeatedly across participants and was analytically salient for understanding how AI interaction externalized metacognitive awareness.

Delayed Recognition of Comprehension Breakdowns

Despite these productive uses, the analysis also revealed instances of delayed recognition of comprehension breakdowns. Some participants continued reading without consulting AI, only to realize later that their understanding was incomplete or inaccurate. In these cases, AI was used retrospectively to reconstruct meaning rather than to monitor comprehension in real time. One participant reflected:

“I thought I understood it, but later when the next section did not make sense, I realized I missed something. Then I asked AI to explain the earlier paragraph.”

This pattern indicates that while AI was available, not all learners consistently monitored their comprehension at appropriate moments. The findings highlight variability in metacognitive sensitivity, suggesting that access to AI alone does not guarantee effective monitoring. Instead, learners’ awareness of breakdowns and willingness to pause reading played a crucial role. Delayed recognition occurred in a smaller subset of cases, but it provides important contrast to more proactive monitoring behaviors and helps delineate limits of AI-supported regulation.

RQ2 Findings: AI Use for Repairing Comprehension Difficulties and Regulating Reading Strategies

With regard to RQ2, the findings show that participants used AI-generated responses in diverse ways to repair comprehension difficulties and regulate their reading strategies. Three main themes were identified, namely strategy-specific repair, iterative regulation through follow-up prompts, and tension between support and overreliance.

Strategy-Specific Repair of Comprehension

Participants employed AI to support specific repair strategies rather than to address comprehension globally. When facing lexical difficulty, they asked for simplified definitions or contextualized meanings. For syntactic complexity, they requested sentence breakdowns or paraphrases. For conceptual difficulty, they asked for examples or background explanations. One participant described this selective use as follows:

“If it is vocabulary, I just ask for the meaning. But if the idea is complex, I ask for an example so I can understand it better.”

Screen recordings confirmed that participants often resumed reading immediately after receiving targeted explanations. This behavior suggests that AI-supported repair was integrated into the reading process rather than treated as a separate activity. The findings indicate that AI facilitated flexible strategy regulation by allowing learners to match specific problems with appropriate forms of support. This strategy-specific use of AI was evident in most participants' reading sessions, indicating a broadly shared regulatory orientation toward AI-mediated repair.

Iterative Regulation Through Follow-Up Prompts

Another prominent theme was the iterative nature of AI-mediated repair. Participants rarely accepted AI responses at face value. Instead, they engaged in follow-up questioning to refine explanations or adjust the level of detail. This iterative interaction reflected ongoing evaluation and control, core components of metacognitive regulation.

For instance, one participant first asked for a summary of a paragraph and then followed up with, “Explain it in simpler terms” and “How does this relate to the previous section?” During interviews, the participant explained:

“The first answer was still difficult, so I asked again. I wanted to make sure I really understood.”

This pattern illustrates how AI enabled a dialogic form of strategy regulation, where learners adjusted their requests based on perceived comprehension. Such interactions support the view of AI as a metacognitive mirror that responds dynamically to learners' regulatory decisions. Although the depth of iteration varied, follow-up prompting was observed across multiple cases and represents a recurring regulatory practice rather than an isolated behaviour.

Tension Between Support and Overreliance

Despite the generally strategic use of AI, the findings also revealed moments of overreliance that potentially limited metacognitive engagement. In some cases, participants accepted AI explanations without cross-checking them against the text, particularly when the explanation was fluent and confident. This was more common among participants with lower self-reported confidence in academic reading. One participant admitted:

“Sometimes I just trust the AI explanation because it sounds clear, and I do not go back to the text.”

Such instances suggest that AI-mediated repair can reduce the need for active evaluation if learners perceive AI as authoritative. This tension highlights a critical boundary of AI as a metacognitive mirror. While AI can support regulation, it can also short-circuit reflective processes when learners disengage from independent verification. Although less frequent than reflective uses, these cases were analytically significant because they illuminate epistemic risks associated with AI-mediated repair.

DISCUSSION

The findings demonstrate that AI served as a metacognitive mirror by enabling EFL students to monitor their understanding, articulate comprehension breakdowns, and regulate repair strategies during academic reading. However, the effectiveness of this mediation depended on learners' metacognitive awareness, confidence, and agency. AI supported both productive reflection and, in some cases, uncritical reliance, underscoring the need for pedagogical guidance in fostering metacognitively responsible AI use. At the same time, it is important to delimit the scope of this claim. Not all AI-supported comprehension activities observed in this study constitute metacognitive regulation. Some instances represent cognitive assistance that may facilitate immediate understanding without necessarily fostering durable metacognitive development. Accordingly, references to AI as a metacognitive mirror in this discussion are restricted to cases in which learners actively evaluated their understanding, diagnosed confusion, or regulated strategy use in response to AI interaction.

This study set out to explore how EFL students use AI as a metacognitive mirror to monitor and repair reading comprehension breakdowns during engagement with academic texts. Rather than evaluating the effectiveness of AI in improving reading performance, the discussion focuses on how AI reshapes metacognitive processes, learner agency, and strategy regulation. This process-oriented focus responds to calls in recent AI-assisted reading research to move beyond outcome-based comparisons and examine learners' real-time engagement with AI tools during cognitively demanding tasks (McCarthy & Yan, 2024; Shafiee Rad, 2025).

One of the most significant contributions of this study lies in its demonstration that AI facilitates the externalization of metacognitive monitoring. Traditionally, monitoring comprehension has been treated as an internal and often tacit process that is difficult for learners to articulate and for researchers to observe (Ghimire & Mokhtari, 2025; Tibken & Tiffin-Richards, 2025). The findings indicate that AI prompts function as external representations of learners' internal monitoring processes. When students formulate prompts to confirm understanding or identify confusion, they make their metacognitive judgments explicit, supporting earlier claims that AI interactions can surface otherwise invisible regulatory processes (Yang & Xia, 2023; Khojasteh et al., 2025).

This externalization aligns with mediated cognition perspectives, which argue that cognitive and metacognitive processes are shaped by the tools available to learners rather than operating solely within the individual (Wheaton et al., 2024; Reinhold et al., 2024). In this study, AI served as a mediational artifact that enabled learners to pause reading, reflect on comprehension, and test interpretations, echoing findings that generative AI can act as a reflective interface for learner thinking (Iqbal et al., 2025; Xu et al., 2024).

Importantly, monitoring was not triggered by the AI itself but by learners' recognition of uncertainty. This suggests that AI amplifies metacognitive awareness rather than generating it independently, supporting arguments that learner agency remains central in AI-mediated learning environments (Jin et al., 2023; Liu & Wang, 2024).

At the same time, the findings reveal that access to AI does not guarantee accurate or timely monitoring. Instances of delayed recognition of comprehension breakdowns highlight the limits of technological mediation. These cases are consistent with previous research showing that many EFL learners struggle to detect comprehension failure even when support tools are available (Allehyani, 2025; Ortiz-Gómez et al., 2025). The findings reinforce the view that metacognitive monitoring is a skill that must be developed and cannot be fully outsourced to AI, even in highly supportive digital environments (Fan et al., 2025).

The findings also extend existing understandings of metacognitive repair by illustrating how AI enables a dialogic form of strategy regulation. Rather than applying fixed strategies such as rereading or dictionary consultation, learners engaged in iterative interactions with AI, adjusting their requests in response to perceived comprehension. This dynamic process reflects a shift from static strategy use to adaptive regulation, which has been identified as a hallmark of effective self-regulated reading (Chang et al., 2023; Wolters et al., 2023).

From a self-regulated learning perspective, this dialogic repair process demonstrates learners' control over strategy selection and modification. AI did not dictate strategies but responded to learners' regulatory decisions, consistent with research emphasizing that AI tools function most productively when they remain responsive rather than directive (Jin et al., 2023; Nguyen et al., 2024). The ability to request paraphrases, examples, or simplified explanations allowed learners to tailor support to specific comprehension problems. This flexibility may be particularly valuable in EFL academic reading, where difficulties vary across lexical, syntactic, and conceptual levels (Habók et al., 2024; Hassan et al., 2025).

However, the dialogic nature of AI-mediated repair also raises questions about the boundaries between support and substitution. While iterative prompting reflects active regulation, repeated reliance on AI explanations may reduce opportunities for independent meaning construction. This concern aligns with emerging evidence that fluent and authoritative AI responses can encourage epistemic passivity and reduce evaluative effort (Essien et al., 2024; Fan et al., 2025). The findings suggest that the pedagogical value of AI lies not in the availability of explanations, but in how learners engage with them as part of a broader regulatory cycle.

From an epistemic cognition perspective, these patterns point to a critical risk in AI-mediated reading. In cases where learners accepted AI output without cross-checking it against the text, AI functioned less as a metacognitive mirror and more as an epistemic authority. The fluency, coherence, and confident tone of AI-generated explanations may suppress productive struggle and reduce learners' willingness to question interpretations or tolerate ambiguity. Such reliance can narrow opportunities for evaluative judgment, shifting the locus of epistemic responsibility away from the learner and toward the tool.

Another key insight from this study concerns the role of learner agency in AI-mediated reading. The findings reveal considerable variation in how students decided when to consult AI, what to ask, and how to interpret AI responses. These decisions reflect learners' beliefs about reading, their confidence in their own comprehension, and their epistemic trust in AI-generated knowledge, echoing earlier observations that AI use patterns are closely tied to metacognitive awareness and self-regulatory competence (Güner & Er, 2025; Kim et al., 2025).

Students who used AI as a metacognitive mirror tended to treat AI responses as provisional rather than authoritative. They compared AI explanations with the text, adjusted their reading accordingly, and continued monitoring their understanding. In contrast, instances of overreliance were characterized by uncritical acceptance of AI output and reduced engagement with the text. This distinction highlights the importance of epistemic cognition in AI use, supporting concerns raised in prior literature about uncritical trust in AI-generated explanations (Raitskaya & Tikhonova, 2025; Liu & Wang, 2024).

These findings contribute to ongoing debates about AI and learner autonomy. Rather than framing AI as either empowering or undermining autonomy, the study suggests that AI amplifies existing patterns of agency. Learners with stronger self-regulatory skills used AI to enhance reflection, while those with lower confidence were more likely to defer to AI, consistent with earlier research on differential AI use across learner profiles (Wei, 2023; Canonigo, 2024). This reinforces the view that AI integration must be accompanied by explicit attention to metacognitive and epistemic development (Xu et al., 2025).

The transferability of these findings should be interpreted in relation to the study's institutional and cultural context. The participants were EFL university students operating in an academic environment characterized by high reading demands, assessment-driven literacy practices, and relatively unrestricted access to generative AI tools. These contextual conditions likely shaped both the frequency and purposes of AI use, particularly the tendency to consult AI during moments of uncertainty or perceived comprehension failure. In educational settings where AI access is limited, assessment norms differ, or independent reading is less emphasized, patterns of AI-mediated monitoring and repair may manifest differently. Therefore, while the conceptual insights regarding AI as a metacognitive mirror may be transferable, their pedagogical implications depend on institutional policies, instructional expectations, and learners' prior experiences with AI.

The concept of AI as a metacognitive mirror invites a rethinking of what it means to comprehend a text in AI-mediated environments. Reading is no longer a solitary interaction between reader and text but a triadic interaction involving the reader, the text, and an intelligent tool. Similar shifts have been noted in recent discussions of AI-supported literacy practices, where comprehension emerges through human–AI collaboration rather than individual cognition alone (Thüs et al., 2024; McCarthy & Yan, 2024).

However, this does not necessarily diminish the cognitive demands of reading. Instead, it shifts some of the effort from decoding and inference to evaluation and regulation.

Learners must decide when AI input is needed, how much to rely on it, and how to integrate it with textual evidence. These decisions represent higher-order metacognitive challenges that are increasingly central to academic literacy in AI-rich environments (Xu et al., 2025; Qassrawi & Al Karasneh, 2025).

The findings also suggest that AI-supported reading may blur the distinction between comprehension and learning. When learners use AI to clarify meaning, they may achieve local understanding without fully internalizing strategies for future reading, echoing concerns in prior research about cognitive offloading and surface-level understanding (Iqbal et al., 2025; Essien et al., 2024). This underscores the importance of pedagogical interventions that encourage learners to reflect on how AI supports their comprehension and how similar strategies can be applied independently.

The study has several implications for pedagogy. First, educators should explicitly frame AI as a metacognitive tool rather than a shortcut to comprehension, aligning with recommendations from AI literacy and self-regulated learning research (Chang et al., 2023; Xu et al., 2025). Instruction can focus on teaching students how to use AI to monitor understanding, formulate diagnostic questions, and critically evaluate responses. Second, reflective activities such as prompt analysis or post-reading journals can help learners become more aware of their metacognitive use of AI, as suggested in prior work on reflective AI engagement (Raitskaya & Tikhonova, 2025). Third, guidance is needed to help learners balance AI support with productive struggle, ensuring that AI enhances rather than replaces strategic reading (Fan et al., 2025; Hassan et al., 2025).

For research, the findings highlight the value of process-oriented methodologies that capture real-time interaction with AI, addressing limitations of survey-based and outcome-focused approaches identified in previous studies (Lin et al., 2025; Shafiee Rad, 2025). Future studies could examine how metacognitive AI use develops over time or how instructional scaffolding influences learners' regulatory practices. Comparative studies across proficiency levels or disciplinary contexts would further enrich understanding of AI as a metacognitive mediator in EFL reading.

CONCLUSION

This study examined how EFL students use AI as a metacognitive mirror to monitor and repair reading comprehension breakdowns during engagement with academic texts. By adopting a process-oriented qualitative approach, the study revealed that AI-mediated reading is not simply a matter of accessing explanations, but a metacognitive activity shaped by learners' awareness, agency, and strategic regulation. The findings show that AI can support comprehension monitoring by enabling learners to externalize uncertainty, confirm interpretations, and diagnose sources of difficulty. AI also facilitated flexible repair strategies through dialogic interaction, allowing learners to adjust their reading approaches in response to perceived comprehension needs. However, the study also highlights important tensions, particularly the risk of uncritical reliance on AI, which may weaken independent evaluation and reduce engagement with the text. These insights underscore the need to conceptualize AI not as a replacement for reading strategies, but as a mediational tool whose value depends on how learners appropriate it.

Conceptually, the notion of AI as a metacognitive mirror is proposed as an analytical lens rather than a fully specified theoretical construct. It extends existing models of metacognition and self-regulated reading by foregrounding the role of external, dialogic tools in making monitoring and regulation processes observable and negotiable in real time. Whereas traditional models typically conceptualize metacognition as an internal cycle of planning, monitoring, and evaluation, this study highlights how AI-mediated interaction enables learners to externalize metacognitive judgments, test interpretations, and reflect on comprehension through interaction with an intelligent artifact. In this sense, AI does not generate metacognition but amplifies learners' awareness of their own regulatory processes, thereby reshaping where and how metacognition is enacted during reading. This positioning allows the concept to function as a heuristic for analyzing AI-mediated literacy practices without reifying AI as an autonomous cognitive agent.

Although participants were allowed to use AI tools of their choice in order to enhance ecological validity, the analysis did not aim to compare tools or isolate the effects of specific technical features. AI systems were treated analytically as mediational artifacts rather than as distinct technological designs. Nevertheless, most observed interactions reflected large language model-based tools characterized by open-ended, dialogic response generation. As a result, the findings should be interpreted primarily as reflective of LLM-style AI interaction, and caution is warranted when transferring them to AI systems with more constrained or task-specific affordances.

Building on these findings, future research should investigate how metacognitive uses of AI in reading develop over time and whether explicit instructional guidance can strengthen learners' monitoring and regulatory skills. Longitudinal studies could examine how repeated AI-mediated reading experiences influence learners' independent strategy use and epistemic judgment. Further research is also needed to explore variations across proficiency levels, academic disciplines, and learning contexts, particularly in informal or out-of-class reading environments where AI use is largely invisible to teachers. Finally, comparative studies examining different types of AI tools and prompt designs would deepen understanding of how specific affordances shape metacognitive engagement in reading. Such research would contribute to more pedagogically responsible and theoretically informed integration of AI in EFL literacy education.

REFERENCES

- Alazemi, A. F. T. (2024). Formative assessment in artificial integrated instruction: Delving into the effects on reading comprehension progress, online academic enjoyment, personal best goals, and academic mindfulness. *Language Testing in Asia*, 14(1), 44. <https://doi.org/10.1186/s40468-024-00319-8>
- Alfahad, M. F. (2025). Implementing the metacognitive pedagogical cycle: Effects on EFL learners' listening achievement, metacognitive awareness, listening self-efficacy, and listening challenges. *Journal of Language Teaching and Research*, 16(3), 932–942. <https://doi.org/10.17507/jltr.1603.23>
- Allehyani, B. (2025). Reading comprehension challenges in the EFL classrooms. *Journal*

- of Language Teaching and Research*, 16(4), 1194–1203. <https://doi.org/10.17507/jltr.1604.14>
- Alshakhi, A. (2025). Use of AI Tools in navigating reading difficulties of adult EFL learners. *World Journal of English Language*, 15(8), 358. <https://doi.org/10.5430/wjel.v15n8p358>
- Andersen, S. C., Nielsen, H. S., & Rowe, M. L. (2022). Development of writing skills within a home-based, shared reading intervention: Re-analyses of evidence from a randomized controlled trial. *Learning and Individual Differences*, 99(August), 102211. <https://doi.org/10.1016/j.lindif.2022.102211>
- Anggia, H., & Habók, A. (2023). Textual complexity adjustments to the English reading comprehension test for undergraduate EFL students. *Heliyon*, 9(1), e12891. <https://doi.org/10.1016/j.heliyon.2023.e12891>
- Aziz, M., & Rawian, R. (2022). Modeling higher order thinking skills and metacognitive awareness in English reading comprehension among university learners. *Frontiers in Education*, 7. <https://doi.org/10.3389/educ.2022.991015>
- Benvenuti, M., Cangelosi, A., Weinberger, A., Mazzoni, E., Benassi, M., Barbaresi, M., & Orsoni, M. (2023). Artificial intelligence and human behavioral development: A perspective on new skills and competences acquisition for the educational context. *Computers in Human Behavior*, 148(December 2022), 107903. <https://doi.org/10.1016/j.chb.2023.107903>
- Brod, G. (2024). There are multiple paths to personalized education, and they should be combined. *Current Directions in Psychological Science*, 33(3), 153–158. <https://doi.org/10.1177/09637214241242459>
- Buele, J., Sabando-García, Á. R., Sabando-García, B. J., & Yáñez-Rueda, H. (2025). Ethical use of generative artificial intelligence among Ecuadorian university students. *Sustainability*, 17(10), 4435. <https://doi.org/10.3390/su17104435>
- Canonigo, A. M. (2024). Levering AI to enhance students' conceptual understanding and confidence in mathematics. *Journal of Computer Assisted Learning*, 40(6), 3215–3229. <https://doi.org/10.1111/jcal.13065>
- Chang, D. H., Lin, M. P.-C., Hajian, S., & Wang, Q. Q. (2023). Educational design principles of using AI chatbot that supports self-regulated learning in education: Goal setting, feedback, and personalization. *Sustainability*, 15(17), 12921. <https://doi.org/10.3390/su151712921>
- Crompton, H., Edmett, A., Ichaporia, N., & Burke, D. (2024). AI and English language teaching: Affordances and challenges. *British Journal of Educational Technology*, 55(6), 2503–2529. <https://doi.org/10.1111/bjet.13460>
- Essien, A., Bukoye, O. T., O'Dea, X., & Kremantzis, M. (2024). The influence of AI text generators on critical thinking skills in UK business schools. *Studies in Higher Education*, 49(5), 865–882. <https://doi.org/10.1080/03075079.2024.2316881>

- Fan, Y., Tang, L., Le, H., Shen, K., Tan, S., Zhao, Y., Shen, Y., Li, X., & Gašević, D. (2025). Beware of metacognitive laziness: Effects of generative artificial intelligence on learning motivation, processes, and performance. *British Journal of Educational Technology*, 56(2), 489–530. <https://doi.org/10.1111/bjet.13544>
- Fitriati, S. W., & Williyana, A. (2025). AI-enhanced self-regulated learning: EFL learners' prioritization and utilization in presentation skills development. *Journal of Pedagogical Research*, 9(2), 22–37. <https://doi.org/https://doi.org/10.33902/JPR.202530647>
- Ghimire, N., & Mokhtari, K. (2025). Evaluating the predictive power of metacognitive reading strategies across diverse educational contexts. *Large-Scale Assessments in Education*, 13(1), 4. <https://doi.org/10.1186/s40536-025-00240-3>
- Güner, H., & Er, E. (2025). AI in the classroom: Exploring students' interaction with ChatGPT in programming learning. *Education and Information Technologies*, 30(9), 12681–12707. <https://doi.org/10.1007/s10639-025-13337-7>
- Habók, A., Oo, T. Z., & Magyar, A. (2024). The effect of reading strategy use on online reading comprehension. *Heliyon*, 10(2), e24281. <https://doi.org/10.1016/j.heliyon.2024.e24281>
- Hassan, M., Najat, M., & Bouchaib, B. (2025). Explicit instruction in metacognitive problem-solving reading strategies: Developing reading comprehension and strategy awareness. *Studies in English Language and Education*, 12(3), 1410–1426. <https://doi.org/10.24815/siele.v12i3.42597>
- Hsiao, J. C., & Chang, J. S. (2023). Enhancing EFL reading and writing through AI-powered tools: design, implementation, and evaluation of an online course. *Interactive Learning Environments*, 1–16. <https://doi.org/10.1080/10494820.2023.2207187>
- Iqbal, J., Hashmi, Z. F., Asghar, M. Z., & Abid, M. N. (2025). Generative AI tool use enhances academic achievement in sustainable education through shared metacognition and cognitive offloading among preservice teachers. *Scientific Reports*, 15(1), 16610. <https://doi.org/10.1038/s41598-025-01676-x>
- Jin, S.-H., Im, K., Yoo, M., Roll, I., & Seo, K. (2023). Supporting students' self-regulated learning in online learning using artificial intelligence applications. *International Journal of Educational Technology in Higher Education*, 20(1), 37. <https://doi.org/10.1186/s41239-023-00406-5>
- Juhkam, M., Jögi, A.-L., Soodla, P., & Aro, M. (2023). Development of reading fluency and metacognitive knowledge of reading strategies during reciprocal teaching: Do these changes actually contribute to reading comprehension? *Frontiers in Psychology*, 14. <https://doi.org/10.3389/fpsyg.2023.1191103>
- Khojasteh, L., Kafipour, R., Pakdel, F., & Mukundan, J. (2025). Empowering medical students with AI writing co-pilots: Design and validation of AI self-assessment toolkit. *BMC Medical Education*, 25(1), 159. <https://doi.org/10.1186/s12909-025->

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- Kim, J., Lee, S.-S., Detrick, R., Wang, J., & Li, N. (2025). Students-Generative AI interaction patterns and its impact on academic writing. *Journal of Computing in Higher Education*. <https://doi.org/10.1007/s12528-025-09444-6>
- Lai, C.-J. (2024). Examining the impact of multimodal task design on English oral communicative competence in fourth-grade content-language integrated social studies: A quasi-experimental study. *Asian-Pacific Journal of Second and Foreign Language Education*, 9(1), 64. <https://doi.org/10.1186/s40862-024-00289-7>
- Lee, S. S., & Moore, R. L. (2024). Harnessing Generative AI (GenAI) for automated feedback in higher education: A systematic review. *Online Learning*, 28(3). <https://doi.org/10.24059/olj.v28i3.4593>
- Lin, C., Lin, T., & Tang, C. (2025). Enhancing English reading comprehension, learning motivation and attitude through AI-supported pre-reading scaffolding. *Journal of Computer Assisted Learning*, 41(6). <https://doi.org/10.1111/jcal.70150>
- Liu, W., & Wang, Y. (2024). The effects of using AI tools on critical thinking in English literature classes among EFL learners: An intervention study. *European Journal of Education*, 59(4). <https://doi.org/10.1111/ejed.12804>
- McCarthy, K. S., & Yan, E. F. (2024). Reading comprehension and constructive learning: Policy considerations in the age of artificial intelligence. *Policy Insights from the Behavioral and Brain Sciences*, 11(1), 19–26. <https://doi.org/10.1177/23727322231218891>
- Momdjian, L., & Chidiac, F. El. (2024). Enhancing English reading comprehension of ESL underachievers by fostering metacognitive strategies. *Theory and Practice in Language Studies*, 14(1), 21–30. <https://doi.org/10.17507/tpls.1401.03>
- Muche, T., Simegn, B., & Shiferie, K. (2024). Self-efficacy and metacognitive strategy use in reading comprehension: EFL learners' perspectives. *The Asia-Pacific Education Researcher*, 33(1), 219–227. <https://doi.org/10.1007/s40299-023-00721-5>
- Mulyadi, D., Singh, C. K. S., Setiawan, A., & Prasetyanti, D. C. (2023). Technology-enhanced task-based language teaching toward their self-directed language learning: ESP learners' views. *Studies in English Language and Education*, 10(3), 1326–1341. <https://doi.org/10.24815/siele.v10i3.27910>
- Mustopa, R. A., Damaianti, V. S., Mulyati, Y., & Anshori, D. S. (2024). Investigating senior high school students' metacognition in Indonesian learning reading comprehension: Does it have a positive impact? *International Journal of Language Education*, 8(2). <https://doi.org/10.26858/ijole.v8i2.64112>
- Nguyen, A., Hong, Y., Dang, B., & Huang, X. (2024). Human-AI collaboration patterns in AI-assisted academic writing. *Studies in Higher Education*, 49(5), 847–864. <https://doi.org/10.1080/03075079.2024.2323593>

- Noipa, J., & Phusawisot, P. (2024). The effects of metacognitive reading strategy instruction on Thai EFL engineering students: Metacognitive strategy use and students' attitudes. *World Journal of English Language*, 15(2), 263. <https://doi.org/10.5430/wjel.v15n2p263>
- Ortiz-Gómez, M., Juárez-Ramírez, R., Solís-Campos, A., Saldaña, D., & Rodríguez-Ortiz, I. R. (2025). A gamified intervention programme for the supervision of reading comprehension in deaf students. *Investigaciones Sobre Lectura*, 20(1), 125–150. <https://doi.org/10.24310/isl.20.1.2025.20424>
- Peng, P., Wang, W., Filderman, M. J., Zhang, W., & Lin, L. (2024). The active ingredient in reading comprehension strategy intervention for struggling readers: A Bayesian network meta-analysis. *Review of Educational Research*, 94(2), 228–267. <https://doi.org/10.3102/00346543231171345>
- Qassrawi, R., & Al Karasneh, S. M. (2025). Redefinition of human-centric skills in language education in the AI-driven era. *Studies in English Language and Education*, 12(1), 1–19. <https://doi.org/10.24815/siele.v12i1.43082>
- Raitskaya, L., & Tikhonova, E. (2025). Enhancing critical thinking skills in ChatGPT-human interaction: A scoping review. *Journal of Language and Education*, 11(2), 5–19. <https://doi.org/10.17323/jle.2025.27387>
- Reinhold, F., Leuders, T., Loibl, K., Nückles, M., Beege, M., & Boelmann, J. M. (2024). Learning mechanisms explaining learning with digital tools in educational settings: A cognitive process framework. *Educational Psychology Review*, 36(1), 14. <https://doi.org/10.1007/s10648-024-09845-6>
- Rohollahzadeh Ebadi, M. (2025). Technology-mediated teaching vocabulary: Exploring EFL learners' depth and breadth of lexical knowledge. *Computer Assisted Language Learning*, 38(5–6), 1198–1222. <https://doi.org/10.1080/09588221.2023.2271530>
- Roseveare, C. (2023). Thematic analysis: A practical guide , by Virginia Braun and Victoria Clarke. *Canadian Journal of Program Evaluation*, 38(1), 143–145. <https://doi.org/10.3138/cjpe.76737>
- Ruffini, C., Pizzigallo, E., Pecini, C., Bertolo, L., & Carretti, B. (2025). Integrating executive function activities into a computerized cognitive training to enhance reading comprehension in primary students. *Reading Research Quarterly*, 60(2). <https://doi.org/10.1002/rrq.70006>
- Shafiee Rad, H. (2025). Reinforcing L2 reading comprehension through artificial intelligence intervention: Refining engagement to foster self-regulated learning. *Smart Learning Environments*, 12(1), 23. <https://doi.org/10.1186/s40561-025-00377-2>
- Srinivasan, V., & Murthy, H. (2021). Improving reading and comprehension in K-12: Evidence from a large-scale AI technology intervention in India. *Computers and Education: Artificial Intelligence*, 2, 100019. <https://doi.org/10.1016/j.caeai.2021.100019>

- Tarchi, C., & Casado Ledesma, L. (2024). Readers' awareness in the use of intertextual strategies when writing from multiple texts. *Journal of Writing Research, 16*(2), 249–269. <https://doi.org/10.17239/jowr-2024.16.02.03>
- Thongsan, N. C., & Anderson, N. J. (2025). From passive answers to active inquiry: How AI supports critical reading in EFL classrooms. *LEARN Journal: Language Education and Acquisition Research Network, 18*(2), 795–820. <https://doi.org/10.70730/KMKL8505>
- Thüs, D., Malone, S., & Brünken, R. (2024). Exploring generative AI in higher education: A RAG system to enhance student engagement with scientific literature. *Frontiers in Psychology, 15*. <https://doi.org/10.3389/fpsyg.2024.1474892>
- Tibken, C., & Tiffin-Richards, S. P. (2025). Reading behavior as an indicator of comprehension monitoring when reading expository texts. *Metacognition and Learning, 20*(1), 38. <https://doi.org/10.1007/s11409-025-09440-2>
- Udry, I., & Berthele, R. (2025). A case study of online and paper bilingual dictionaries and their impact on vocabulary learning through meaning-focused reading. *International Journal of Lexicography, 38*(3), 219–237. <https://doi.org/10.1093/ijl/ecaf004>
- Wang, T., Li, S., Tan, C., Zhang, J., & Lajoie, S. P. (2023). Cognitive load patterns affect temporal dynamics of self-regulated learning behaviors, metacognitive judgments, and learning achievements. *Computers and Education, 207*, 104924. <https://doi.org/10.1016/j.compedu.2023.104924>
- Wang, Y. (2025). Reducing anxiety, promoting enjoyment and enhancing overall English proficiency: The impact of AI-assisted language learning in Chinese <scp>EFL</scp> contexts. *British Educational Research Journal*. <https://doi.org/10.1002/berj.4187>
- Wang, Y., Hu, J., An, Z., Li, C., & Zhao, Y. (2023). The influence of metacognition monitoring on L2 Chinese audiovisual reading comprehension. *Frontiers in Psychology, 14*. <https://doi.org/10.3389/fpsyg.2023.1133003>
- Wangdi, T., & Shimray, R. (2025). AI-powered readtheory as a self-access learning platform to enhance EFL learners' reading enjoyment and comprehension skills: A posthumanist perspective. *Studies in Self-Access Learning Journal, 16*(2), 437–460. <https://doi.org/10.37237/160209>
- Wei, L. (2023). Artificial intelligence in language instruction: Impact on English learning achievement, L2 motivation, and self-regulated learning. *Frontiers in Psychology, 14*(November), 1–14. <https://doi.org/10.3389/fpsyg.2023.1261955>
- Wheaton, M., Ardoin, N. M., Bowers, A. W., & Kannan, A. (2024). Sociocultural learning theories for social-ecological change. *Environmental Education Research, 30*(8), 1193–1210. <https://doi.org/10.1080/13504622.2024.2347888>
- Wolters, C. A., Iaconelli, R., Peri, J., Hensley, L. C., & Kim, M. (2023). Improving self-

- regulated learning and academic engagement: Evaluating a college learning to learn course. *Learning and Individual Differences*, 103(March), 102282. <https://doi.org/10.1016/j.lindif.2023.102282>
- Xu, X., Qiao, L., Cheng, N., Liu, H., & Zhao, W. (2025). Enhancing self-regulated learning and learning experience in generative AI environments: The critical role of metacognitive support. *British Journal of Educational Technology*, 56(5), 1842–1863. <https://doi.org/10.1111/bjet.13599>
- Xu, X., Wang, X., Zhang, Y., & Zheng, R. (2024). Applying ChatGPT to tackle the side effects of personal learning environments from learner and learning perspective: An interview of experts in higher education. *PLOS ONE*, 19(1), e0295646. <https://doi.org/10.1371/journal.pone.0295646>
- Yang, Y., & Xia, N. (2023). Enhancing students' metacognition via AI-driven educational support systems. *International Journal of Emerging Technologies in Learning (IJET)*, 18(24), 133–148. <https://doi.org/10.3991/ijet.v18i24.45647>
- Yin, J., Xu, H., Pan, Y., & Hu, Y. (2025). Effects of different AI-driven Chatbot feedback on learning outcomes and brain activity. *Npj Science of Learning*, 10(1), 17. <https://doi.org/10.1038/s41539-025-00311-8>
- Yuan, H. (2025). Artificial intelligence in language learning: Biometric feedback and adaptive reading for improved comprehension and reduced anxiety. *Humanities and Social Sciences Communications*, 12(1), 556. <https://doi.org/10.1057/s41599-025-04878-w>
- Zhu, T., Zhang, Y., & Irwin, D. (2024). Second and foreign language vocabulary learning through digital reading: A meta-analysis. *Education and Information Technologies*, 29(4), 4531–4563. <https://doi.org/10.1007/s10639-023-11969-1>