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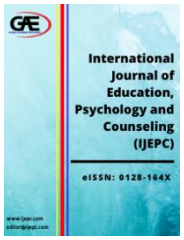

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GRAMMAR ACHIEVEMENT IN AI-SUPPORTED EFL LEARNING: ACADEMIC ENGAGEMENT, AI LITERACY, AND TASK-ASSESSMENT ALIGNMENT

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Abstract:

As artificial intelligence (AI) becomes increasingly integrated into higher education, grammar achievement in English as a Foreign Language (EFL) context remains uneven, suggesting that technology alone is insufficient to ensure effective learning. Existing research has often examined AI-supported learning, academic engagement, AI literacy, and grammar achievement separately, leaving unclear how these factors interact under conditions of task-assessment alignment. This review adopts a targeted conceptual narrative approach to examine how academic engagement and AI literacy shape grammar achievement in AI-supported environments. Drawing on a narrative synthesis of research in language education, educational psychology, and learning analytics, this review identifies key mechanisms underlying grammar learning outcomes. The synthesis indicates that academic engagement functions as a proximal learning mechanism through which grammar-related learning processes are sustained, while AI literacy serves as an enabling condition that shapes the quality of learner engagement. In addition, task-assessment alignment is identified as a validity constraint influencing whether AI-supported learning behaviours meaningfully reflect assessed outcomes. This review proposes a novel mechanism-condition-constraint framework and provides a theoretically grounded basis for designing engagement-driven tasks, scaffolding learner AI

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literacy, and aligning AI-supported learning activities with grammar assessment in higher education EFL contexts.

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Keyword:

Academic Engagement; AI Literacy; AI-Supported Learning; EFL Learning; Grammar Achievement; Task-Assessment Alignment

Introduction

Grammar achievement remains an important indicator of learners' grammatical ability and broader academic language development in English as a Foreign Language (EFL) education. Rather than being understood as the memorisation of isolated rules, grammar learning involves the gradual development of form-meaning connections through instruction, meaningful input, practice, and feedback (Ellis, 2006). In this sense, grammar achievement reflects not only students' knowledge of grammatical forms but also their ability to understand and use these forms meaningfully in language-use contexts. From a functional and assessment-oriented perspective, grammar extends beyond formal accuracy to include the relationship between linguistic forms, semantic meanings, and contextual use, which enables learners to construct and interpret meaning in communication (Purpura, 2014). Therefore, grammar achievement provides a relevant outcome for examining how academic engagement, AI literacy, and task-assessment alignment may shape learning in AI-supported EFL contexts.

With the rapid advancement of artificial intelligence (AI) in higher education, AI-supported learning environments are beginning to reshape EFL grammar learning by extending practice, feedback, and learner support beyond conventional classroom boundaries. At a broader level, UNESCO policy guidance emphasises both the educational potential of AI and the need for ethical, inclusive, and human-centred integration into teaching and learning environments (UNESCO, 2021). Contemporary digital and AI-supported platforms can provide adaptive practice, automated or semi-automated feedback, and personalised learning pathways, enabling learners to interact with instructional content more flexibly. However, platform affordances do not automatically translate into improved learning outcomes. From a user-experience perspective, educational information-system platforms may fail to accommodate diverse learning preferences because of design mismatches, interface complexity, or limited adaptability, which can negatively affect student engagement and achievement (Yang & Singh, 2024).

In parallel, learning analytics embedded within these environments allow educators and researchers to capture and analyse behavioural data, offering insights into learners' participation patterns and performance trajectories. Yet observable platform traces should not

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be treated as direct evidence of deeper learning. Learning analytics can record behavioural indicators such as clicks, task duration, logins, and completion rates, but these indicators may not validly represent learners' cognitive engagement, affective investment, self-regulation, or intrinsic motivation (Bergdahl et al., 2024). This limitation is particularly important in grammar learning, where successful achievement depends not only on task completion but also on meaningful form–meaning connections, sustained practice, effective processing of corrective feedback, and assessment-relevant language use (Ellis, 2006; Purpura, 2014). Recent developments in large language models may further extend learning analytics by supporting more interpretable insights, personalised feedback, and process-oriented analysis, but these developments also require stronger pedagogical grounding and careful attention to the validity of learner-data interpretation (Mazzullo et al., 2023). Therefore, the key issue is not simply whether AI-supported platforms generate more learning data, but whether AI literacy and academic engagement enable learners to convert AI-supported affordances into grammar-relevant learning outcomes.

Despite these technological advancements, the educational value of AI-supported learning environments cannot be inferred from the availability of intelligent tools alone. In grammar learning, AI platforms may provide practice opportunities, feedback, and learning traces, but these affordances do not automatically explain why some learners transform such support into measurable achievement whereas others do not. This suggests a need to move beyond technology-centred explanations and examine learner-related mechanisms that shape how AI-supported affordances are used for grammar learning. From a self-regulated learning perspective, students' learning outcomes depend partly on how they set goals, manage time, use strategies, monitor progress, and evaluate their own performance (Zimmerman, 2002). Accordingly, self-regulated learning is used in the present review as a theoretical lens for explaining whether students can use AI-supported learning opportunities in a sustained and purposeful manner.

Among these mechanisms, academic engagement has been widely recognised as an important factor associated with learning and academic success. Engagement is commonly understood as a multidimensional construct comprising behavioural, emotional, and cognitive components (Fredricks et al., 2004; Fredricks et al., 2016). This multidimensional view is particularly relevant to AI-supported EFL learning because observable platform participation alone cannot fully represent learners' emotional investment or cognitive effort. Therefore, academic engagement should be understood not merely as task completion or platform use, but as the extent to which students participate, invest effort, and cognitively process grammar-related learning tasks. In this sense, engagement provides a proximal mechanism through which learning opportunities may become achievement-relevant learning behaviour.

At the same time, the increasing integration of AI technologies into language learning has highlighted the importance of learners' capacity to understand and use such tools effectively. This capacity, often conceptualised as AI literacy, extends beyond basic digital competence to include the ability to understand AI applications, use AI tools appropriately, evaluate AI-generated outputs critically, and consider ethical implications (Long & Magerko, 2020; Ng et al., 2021; Ng et al., 2024). Learners with stronger AI literacy are therefore more likely to interpret automated feedback, judge the relevance and accuracy of AI-generated suggestions, and use AI tools strategically rather than passively. However, AI literacy alone may not improve grammar achievement if it is not accompanied by sustained academic engagement and self-regulated learning practices. This creates the central gap addressed in this review: existing

studies have often examined AI-supported learning, student engagement, or AI literacy separately, while limited attention has been given to how academic engagement, AI literacy, self-regulated learning, and grammar achievement are theoretically connected through learner mechanisms and task–assessment alignment in AI-supported EFL contexts.

However, existing research streams on academic engagement, AI literacy, and grammar assessment remain only loosely connected. Many studies examine these constructs independently, with limited attention to their interaction or to grammar achievement as a distinct and theoretically meaningful outcome. Furthermore, recent work in learning analytics raises concerns about the validity of platform-generated behavioural traces, as platform-based measures often capture surface-level participation rather than deeper learning processes (Bergdahl et al., 2024). This raises a critical issue regarding whether AI-supported learning behaviours can be meaningfully linked to assessed grammar outcomes rather than interpreted merely as indicators of task completion or platform participation.

To address these gaps, the present review develops a theoretically grounded synthesis of research on grammar achievement in AI-supported EFL contexts. Specifically, it integrates academic engagement as a proximal learning mechanism, AI literacy as an enabling condition for effective and critical AI use, and task‑assessment alignment as a validity constraint in grammar assessment (Bergdahl et al., 2024; Long & Magerko, 2020; Ng et al., 2021; Ng et al., 2024; Purpura, 2014). By moving beyond isolated discussions of technology use, engagement, and grammar performance, this review aims to provide a coherent framework for understanding how AI-supported learning can become pedagogically meaningful and assessment-relevant in higher education EFL contexts.

Grammar achievement may vary across instructional and post-instructional phases because grammar development is cumulative, feedback-sensitive, and not always captured fully by short-term post-instruction performance. Ellis (2006) argues that grammar acquisition is a complex process, that instructional effects should be examined over time, and that corrective feedback may become evident gradually through repeated exposure. In assessment terms, Purpura (2014) also cautions that knowledge of grammatical forms in isolation does not necessarily translate into meaningful language use, indicating that grammar outcomes depend partly on whether learning tasks and assessments elicit form‑meaning use in context. Therefore, short-term completion of AI-supported practice tasks should not be treated as sufficient evidence of durable grammar achievement.

From a learning psychology perspective, such variability in grammar achievement can be associated with fluctuations in learners' academic engagement beyond the instructional phase. Engagement is not a single behaviour but a multidimensional construct involving behavioural participation, emotional investment, and cognitive strategy use; it is also shaped by learning contexts and linked to academic success (Fredricks et al., 2004; Fredricks et al., 2016). Similarly, self-regulated learning involves learners' goal setting, strategic action, self-monitoring, time management, and self-evaluation, and learners' performance may vary according to the presence or absence of these regulatory processes (Zimmerman, 2002). In AI-supported grammar learning, this means that learners who merely complete platform tasks may not necessarily consolidate grammatical knowledge unless they remain cognitively engaged, monitor feedback, and adapt their learning strategies.

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These patterns suggest that grammar achievement cannot be adequately explained by instructional exposure alone. Nor can it be explained by technological access alone. Rather, it reflects the extent to which learners maintain sustained engagement with grammatical forms and meanings, use AI tools critically, and respond to feedback in ways that are aligned with assessment-relevant language use. In this sense, grammar achievement should be understood not merely as the immediate outcome of instruction, but as a dynamic result of continued engagement, AI-literate tool use, feedback processing, practice, and self-regulated learning processes.

Additional insights from aggregated institutional assessment data further illustrate this issue. In large-scale English examinations, grammar-relevant differences can be illustrated through productive tasks, such as writing and translation, because these tasks require learners to mobilise grammatical resources to construct accurate and meaningful language rather than merely recognise isolated forms (Purpura, 2014). Such tasks also require attention to form, self-monitoring, and strategic control during language production (Ellis, 2006; Zimmerman, 2002). Therefore, higher performance in writing and translation may indicate stronger control over grammatical forms in use, although these scores should not be interpreted as pure measures of grammar achievement.

As an illustrative example, aggregated institutional data (see Table 1) reveal substantial differences in grammar-relevant productive performance between higher- and lower-performing learners. These descriptive patterns are consistent with the view that grammar achievement is associated with active language processing and sustained engagement (Fredricks et al., 2004; Purpura, 2014), but they should not be interpreted as causal evidence. They nevertheless help contextualise why passive exposure to instructional input or platform tasks may be insufficient for stable grammar-related outcomes.

Taken together, these observations highlight a central challenge in grammar education: while instructional input is necessary, it is insufficient on its own to ensure durable achievement. Instead, sustained academic engagement and the conditions that support it must be considered an important mechanism for explaining variability in grammar achievement. This challenge provides a conceptual foundation for examining how engagement processes, AI-related competencies, and task‑assessment alignment jointly shapes learning outcomes in AI-supported EFL environments.

Table 1: Illustrative Institutional Evidence of Grammar-Relevant Productive Performance Patterns

Indicator	Description	Value
Valid sample (n)	After data cleaning	7,461
Passed CET-4 (≥ 425)	Number and proportion	1,996 (26.75%)
Failed CET-4 (<425)	Number and proportion	5,465 (73.25%)
Grammar-related productive mean score (passed group)	Writing + Translation	146.94
Grammar-related productive mean score (failed group)	Writing + Translation	88.12

Source: Aggregated institutional data provided by the Academic Affairs Office of Guangzhou Xinhua University.

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Note: The data are presented for illustrative and contextual purposes only and are not intended for statistical inference. Writing and translation scores are treated as indicators of grammar-relevant productive performance, not as pure or isolated measures of grammar achievement.

Methodology

This review adopts a targeted conceptual narrative review design to synthesise existing research on grammar achievement in AI-supported EFL contexts. Unlike empirical studies that rely on primary data collection and statistical analysis, this review aims to develop a theoretically grounded understanding of how learner-related factors interact to shape grammar achievement. This design was selected because the purpose of the review is conceptual integration rather than exhaustive evidence aggregation or effect-size estimation (Snyder, 2019). A narrative synthesis approach is employed to integrate findings across studies and to identify recurring conceptual patterns, mechanisms, and gaps in the literature. The review therefore does not claim to be a systematic review and does not follow PRISMA procedures; instead, it follows a transparent and purposive search-and-synthesis logic appropriate for conceptual framework development, with explicit attention to the reporting of sources, search terms, inclusion and exclusion criteria, and synthesis procedures (Snyder, 2019; Popay et al., 2006).

Relevant literature was identified through a targeted search of major academic sources, including Web of Science, Scopus, ERIC, and Google Scholar as a supplementary academic search engine. The search focused on peer-reviewed journal articles, scholarly books, book chapters, and indexed or reputable conference proceedings published in English. Key search terms included combinations of "academic engagement," "student engagement," "AI literacy," "artificial intelligence in education," "learning analytics," "grammar achievement," "grammar assessment," "EFL learning," "task-assessment alignment," and "assessment validity." In addition, backward and forward citation tracking was conducted to identify influential studies that may not have appeared in the initial search. The search focused primarily on literature published between 2014 and 2025, while earlier seminal works were retained when they provided foundational theoretical support for engagement, self-regulated learning, grammar assessment, or assessment validity.

To ensure relevance and quality, the inclusion criteria focused on studies that addressed academic engagement, AI literacy, learning analytics, or AI-supported learning in educational contexts; research related to EFL learning, second language acquisition, grammar learning, or grammar assessment; and studies providing theoretical, empirical, or methodological insights into learner engagement, AI literacy, grammar-related outcomes, or task-assessment alignment. Only publications in peer-reviewed journals or other reputable academic sources were considered. Conceptual and theoretical works were included when they directly supported the development of the mechanism-condition-constraint framework.

Studies were excluded if they focused solely on technical aspects of AI without educational application, addressed general digital literacy without specific relevance to AI-supported learning, discussed language learning without connection to grammar-related outcomes or assessment, or lacked sufficient conceptual or methodological clarity. Studies were also excluded when they used platform participation data without clarifying how such indicators were linked to learning processes or assessed outcomes.

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The selected studies were analysed using a mechanism-oriented thematic synthesis approach. Rather than aggregating statistical findings, the analysis focused on identifying how key constructs, namely academic engagement, AI literacy, and task–assessment alignment, are conceptualised and how they interact to influence grammar achievement. The synthesis was informed by the logic of thematic analysis, moving from repeated reading and coding of relevant ideas to the development of descriptive themes and higher-level analytical themes (Thomas & Harden, 2008). Particular attention was given to theoretical frameworks such as self-regulated learning, self-determination theory, student engagement theory, AI literacy frameworks, and assessment validity theory, which provide explanatory mechanisms for learner engagement, AI-supported tool use, and the interpretation of grammar-related outcomes. Through iterative comparison and abstraction, recurring patterns were organised into a mechanism–condition–constraint framework. Academic engagement was conceptualised as a proximal mechanism driving learning processes, AI literacy as an enabling condition shaping the quality of engagement, and task–assessment alignment as a validity constraint affecting the interpretation of learning outcomes.

Aggregated institutional assessment data, where reported, were used only as contextual and illustrative evidence. They were not treated as primary empirical data for statistical inference, nor were they used to test causal relationships. Instead, they helped contextualise the practical relevance of grammar-relevant productive performance in higher education EFL assessment.

As a narrative review, this review does not aim to provide exhaustive coverage of all available studies or to conduct meta-analytic statistical synthesis. Instead, it prioritises conceptual depth and theoretical integration. While this approach allows for the development of a coherent explanatory framework, it may be subject to selection bias and does not quantify effect sizes or causal relationships. Future research employing systematic review, meta-analysis, longitudinal design, or empirical modelling is needed to validate and extend the proposed framework.

Literature Review

This section synthesises theoretically relevant and methodologically robust studies in language education, learning analytics, and AI-supported learning, integrating both theoretical and empirical research on academic engagement, AI literacy, and grammar achievement in EFL contexts. Emphasising conceptual relevance and theoretical contribution, the review adopts a mechanism-oriented perspective to examine how these key constructs interact in shaping grammar achievement and to identify critical gaps in the existing literature.

Academic Engagement and Grammar Achievement

Academic engagement has been widely recognised as an important factor associated with academic achievement (Fredricks et al., 2004; Lei et al., 2018). It is typically conceptualised as a multidimensional construct encompassing behavioural participation, emotional involvement, and cognitive investment in learning activities (Fredricks et al., 2004). The cognitive dimension of engagement is closely aligned with self-regulated learning theory, which emphasises learners' goal setting, strategy use, self-monitoring, and self-evaluation during learning (Zimmerman, 2002).

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From a theoretical standpoint, engagement can function as a proximal process through which instructional conditions are translated into learning outcomes. Within the framework of self-determination theory, engagement is sustained when learners' basic psychological needs for autonomy, competence, and relatedness are supported (Deci & Ryan, 2000; Reeve, 2012). When these needs are fulfilled, learners are more likely to demonstrate intrinsic motivation and sustained involvement in learning activities. In contrast, when learning is driven primarily by external regulation, engagement may become less self-determined and less stable over time, thereby weakening its contribution to long-term achievement.

Empirical research has demonstrated a positive association between academic engagement and achievement (Fredricks et al., 2004; Lei et al., 2018). Meta-analytic findings indicate that overall engagement and its behavioural, emotional, and cognitive dimensions are positively associated with academic performance across general educational contexts. However, the strength of this relationship varies depending on how engagement is conceptualised and measured. Lei et al. (2018) found that behavioural engagement showed the strongest average correlation with academic achievement, followed by cognitive and emotional engagement, and that the engagement–achievement relationship was moderated by reporting method, cultural value, and gender. Therefore, engagement should not be treated as a uniform construct, especially when it is used to explain specific learning outcomes such as grammar achievement. In digital learning environments, engagement can also be operationalised through behavioural data derived from learners' interactions with learning systems. Such data provide valuable insights into participation patterns and learning processes. At the same time, recent research indicates the importance of distinguishing observable behavioural participation from cognitive, emotional, social, and agentic dimensions of engagement, including learners' self-regulation, cognitive investment, and proactive contribution to learning activities (Bergdahl et al., 2024; Reeve, 2012). This distinction is particularly important in AI-supported and learning-analytics contexts, where surface-level interaction, such as clicks, logins, task completion, or time-on-task, does not necessarily reflect meaningful cognitive engagement or deeper learning.

Grammar achievement may be particularly sensitive to variations in engagement because grammar development involves sustained attention to form‑meaning relationships, repeated practice, corrective feedback, and the ability to use grammatical resources meaningfully in context (Ellis, 2006; Purpura, 2014). As a result, engagement functions as a key mechanism linking instructional activities to grammar achievement. Learners who actively participate in practice tasks, persist in the face of difficulty, process feedback, and engage in self-monitoring are more likely to consolidate grammatical knowledge and achieve stable performance outcomes.

Despite these insights, important gaps remain in the literature. First, much of the existing research focuses on general academic achievement or overall language proficiency, with limited attention to grammar achievement as a distinct outcome with unique learning demands. Second, engagement is often treated as a unitary construct, which obscures the differential contributions of its behavioural, emotional, and cognitive components. Finally, insufficient attention has been paid to how engagement interacts with other factors, such as AI literacy and task–assessment alignment, in shaping achievement outcomes in AI-supported environments.

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AI Literacy as an Enabling Condition for Grammar Achievement

With the increasing integration of artificial intelligence in education, AI literacy has emerged as a critical learner-related construct in AI-supported learning environments. AI literacy is better understood as a multidimensional competence that includes affective, behavioural, cognitive, and ethical dimensions, rather than merely the ability to operate AI tools. It involves learners' capacity to understand AI, use AI applications appropriately, evaluate AI-generated outputs critically, and consider ethical implications in AI-supported learning contexts (Ng et al., 2024). In language education, this competence is closely related to learners' ability to use AI feedback and resources in self-regulated ways (Mohebbi, 2025).

In language learning contexts, AI-supported platforms provide features such as automated feedback, adaptive exercises, and data-driven learning recommendations. Recent evidence suggests that AI-supported language tools can facilitate language learning by providing immediate feedback, personalised learning support, and opportunities for autonomous practice (Mohebbi, 2025). More specifically, Lu (2025) found that an AI-generated corpus intervention improved EFL learners' grammatical knowledge, lexical-bundle acquisition, and willingness to write in a repeated-measures quasi-experimental study. While these affordances create new opportunities for individualised learning, their effectiveness depends largely on how learners interact with them. In particular, learners must be able to interpret AI-generated feedback, regulate their responses, and integrate system suggestions into their learning processes. This highlights that the impact of AI on learning outcomes is not automatic but conditioned by learners' capacity to use AI tools critically, strategically, and reflectively.

From this perspective, AI literacy can be conceptualised as an enabling condition that shapes the quality of learners' engagement in AI-supported environments. Learners with higher levels of AI literacy are more likely to engage in self-regulated learning, critically evaluate system outputs, and use AI tools strategically rather than passively. In contrast, learners with limited AI literacy may rely on superficial interaction with AI systems, which can result in lower-quality engagement and reduced learning effectiveness.

In the context of grammar learning, this distinction is particularly important. AI-supported grammar instruction often relies on automated feedback and practice systems that require learners to actively process input, identify errors, and apply corrective strategies. When learners engage meaningfully with these processes, AI tools can support the development of grammatical accuracy. However, when interaction remains at the level of task completion or passive response to feedback, the potential benefits of AI are substantially reduced. This concern is consistent with recent review evidence showing that AI grammar tools may improve correction and accuracy, but surface-level correction does not necessarily lead to deeper grammatical understanding or effective communicative use (Mohebbi, 2025).

This variation helps explain why the effectiveness of AI-supported grammar learning is often inconsistent across learners. Rather than functioning as a direct predictor of achievement, AI literacy conditions how engagement processes are enacted in AI-supported environments. In this sense, grammar achievement is influenced not simply by the presence of AI tools, but by the extent to which learners can use these tools to support sustained and meaningful engagement with language forms.

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Despite its importance, research on AI literacy in relation to grammar achievement remains limited. Existing studies tend to focus on writing performance or general language outcomes, with comparatively little attention to grammar as a distinct and theoretically meaningful domain. Furthermore, AI literacy is often treated as a static individual attribute, with insufficient consideration of how it dynamically interacts with engagement processes in shaping learning outcomes. This gap is important because AI literacy may enable learners to transform AI-supported feedback into grammar-relevant learning only when it is accompanied by sustained academic engagement, self-regulated practice, and task‑assessment alignment.

Unresolved Issues and Research Gaps

Although prior research indicates the importance of academic engagement and AI-related competencies in language learning, several critical gaps remain in understanding grammar achievement in AI-supported EFL contexts.

A major limitation in the existing literature is the lack of integrative examination of academic engagement and AI literacy. These constructs are typically investigated in isolation, which restricts a comprehensive understanding of how engagement processes and AI-related competencies interact to influence grammar-relevant learning outcomes in AI-supported environments.

Another concern relates to inconsistencies in the conceptualisation and operationalisation of both academic engagement and AI literacy, alongside the limited attention to grammar achievement as a distinct outcome. Variations in definitions and measurement approaches, ranging from self-reported perceptions to behavioural indicators derived from learning analytics, reduce the comparability of findings and obscure the mechanisms through which these constructs influence achievement. At the same time, grammar achievement is often subsumed under broader measures of language proficiency, overlooking its domain-specific characteristics such as cumulative knowledge development, sustained practice, form–meaning mapping, and form-focused processing.

Most critically, insufficient attention has been paid to the issue of task‑assessment alignment in AI-supported learning environments. While AI-supported platforms generate extensive platform-based learning-analytics traces, these indicators often reflect task completion or surface-level interaction rather than the competencies assessed in formal grammar evaluations. This misalignment raises fundamental concerns regarding the validity of using platform-generated behavioural indicators to explain or predict grammar achievement.

Taken together, these limitations indicate the need for a more integrated and theoretically grounded perspective. Specifically, there is a need to move beyond examining isolated constructs toward a mechanism-based understanding of how engagement processes, AI-related competencies, and assessment design jointly shape grammar achievement.

To address these gaps, the present review proposes a conceptual framework that integrates academic engagement as a proximal mechanism, AI literacy as an enabling condition, and task‑assessment alignment as a validity constraint. This framework provides a theoretically coherent explanation of grammar achievement in AI-supported EFL contexts and forms the basis of the

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model presented in Figure 1. It illustrates how academic engagement (mechanism), AI literacy (condition), and task‑assessment alignment (constraint) jointly shapes grammar achievement.

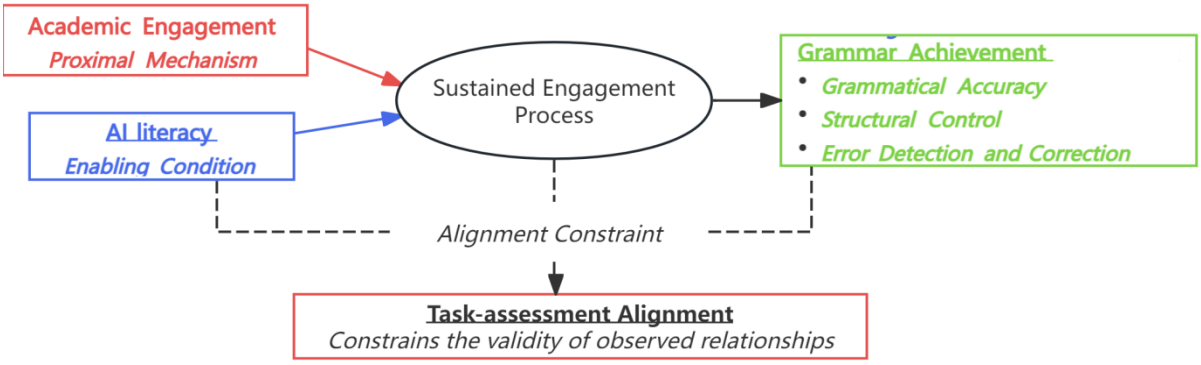

Figure 1: Grammar Achievement Framework in AI-Supported EFL Learning
Source: Authors' conceptual framework.

Findings

Building on the synthesis of existing theoretical and empirical studies, several key generalisations can be derived regarding the mechanisms underlying grammar achievement in AI-supported EFL contexts. Rather than representing definitive causal claims, these generalisations highlight recurring patterns that inform a theoretically integrated understanding of grammar achievement.

The reviewed literature suggests a close association between grammar achievement and sustained academic engagement. Learners who maintain higher levels of active participation, affective involvement, and cognitive investment tend to demonstrate more favourable grammar-related development and achievement outcomes (Fredricks et al., 2004; Lei et al., 2018). Given the cumulative and practice-sensitive nature of grammar learning, academic engagement functions as a proximal mechanism through which instructional conditions are translated into achievement-relevant learning processes (Ellis, 2006; Purpura, 2014; Reeve, 2012).

Importantly, academic engagement should be understood as a dynamic process rather than a fixed learner characteristic. In AI-supported learning environments, engagement reflects the extent to which learners actively participate in practice, persist in learning tasks, and allocate cognitive effort to processing grammatical input. Because observable participation alone does not fully capture cognitive, emotional, social, or agentic engagement, variability in engagement quality may contribute to differences in grammar achievement, even when learners are exposed to similar instructional resources (Bergdahl et al., 2024; Reeve, 2012).

At the same time, AI literacy operates as an enabling condition that shapes how engagement processes are enacted in AI-supported environments. Rather than directly determining grammar achievement, AI literacy influences learners' ability to interpret automated feedback, regulate their learning strategies, and make informed use of AI-supported tools (Ng et al., 2024; Mohebbi, 2025). Learners with higher levels of AI literacy are better positioned to transform

engagement into effective learning processes, whereas limited AI literacy may constrain the quality of engagement.

In addition, AI-supported environments may amplify individual differences in engagement quality. While such platforms provide increased access to practice opportunities and feedback, these affordances do not function uniformly across learners. Instead, the effectiveness of AI-supported learning depends on the extent to which learners combine sustained engagement with the capacity to use AI tools strategically and reflectively.

Crucially, the relationship between AI-supported learning behaviours and grammar achievement is further shaped by task-assessment alignment, which operates as a validity constraint. When learning activities and assessment demands are aligned, engagement and AI-supported behaviours are more likely to translate into measurable grammar-relevant achievement. Conversely, when misalignment occurs, platform-generated behavioural traces may fail to meaningfully reflect learners' grammatical competence, thereby weakening the observed relationship between engagement and achievement (Bergdahl et al., 2024; Purpura, 2014).

Taken together, these generalisations suggest that grammar achievement in AI-supported EFL contexts is best understood as the outcome of a mechanism-condition-constraint system. Academic engagement drives learning processes as a proximal mechanism, AI literacy shapes the quality of these processes as an enabling condition, and task-assessment alignment determines whether these processes are validly captured in assessment outcomes. This integrated perspective provides a coherent theoretical basis for understanding and optimising grammar achievement in AI-supported learning environments.

Discussion

The purpose of this discussion is to interpret the synthesised findings through a mechanism-based perspective and to situate them within broader research on grammar learning, academic engagement, and AI-supported education. By integrating these strands of research, the present review moves beyond descriptive synthesis to offer a theoretically grounded explanation of grammar achievement in AI-supported EFL contexts.

The findings highlight the central role of academic engagement as a proximal mechanism underlying grammar achievement. Consistent with established perspectives in educational psychology, engagement can function as a mediating process through which motivational and instructional conditions are translated into learning outcomes (Reeve, 2012). Notably, grammar learning appears particularly sensitive to the continuity of engagement over time. Given its cumulative and practice-sensitive nature, reductions in sustained participation, cognitive effort, or feedback processing may hinder the consolidation of grammatical knowledge, thereby contributing to unstable achievement outcomes (Ellis, 2006; Purpura, 2014).

The findings further clarify the role of AI literacy as an enabling condition rather than a direct determinant of achievement. While AI-supported tools provide adaptive feedback and flexible learning opportunities, their effectiveness depends on learners' capacity to interpret and act on AI-generated feedback and platform-provided information. This perspective helps reconcile inconsistent findings in AI-supported language learning research. Rather than asking whether

AI improves learning outcomes, the present review suggests that the key issue lies in how learners use AI tools. Learners with higher AI literacy are more likely to transform engagement into effective learning processes through self-regulation, critical evaluation, and strategic use of feedback (Ng et al., 2024; Mohebbi, 2025).

Moreover, the interaction between academic engagement and AI literacy provides a more nuanced explanation of learner variability in AI-supported environments. AI-supported platforms do not function as neutral or automatically equalising tools; instead, they may intensify differences in learners' engagement quality and strategic competence. Highly engaged learners with sufficient AI literacy are better positioned to benefit from adaptive learning systems, whereas learners with lower engagement or limited AI literacy may engage only superficially with available resources. This interactional perspective shifts the focus from technology as an independent factor to learner‑technology interaction as a key determinant of learning outcomes.

Importantly, the present review further suggests the role of task‑assessment alignment as a validity constraint in interpreting AI-supported learning behaviours. While learning analytics provide detailed records of learner activity, these indicators often capture task completion or surface-level interaction rather than the competencies assessed in formal evaluations (Bergdahl et al., 2024). When learning activities are not aligned with assessment demands, engagement and AI-supported behaviours may fail to translate into measurable grammar achievement. This insight suggests that inconsistencies in prior research may not only reflect variability in learner characteristics, but also limitations in how learning is measured and evaluated in AI-supported contexts.

From a practical perspective, these findings point to three key instructional design principles for improving grammar achievement in AI-supported environments. First, instructional design should prioritise engagement-driven learning, ensuring that tasks promote sustained participation, cognitive effort, and meaningful interaction with grammatical forms. Second, AI literacy scaffolding should be incorporated into instruction, enabling learners to interpret feedback, regulate their learning strategies, and use AI tools critically and effectively. Third, alignment-oriented assessment design is essential to ensure that learning activities, platform-generated indicators, and assessment tasks target the same underlying competencies. Without such alignment, improvements in engagement or AI use may not be reflected in assessment outcomes.

Overall, this discussion supports a mechanism–condition–constraint perspective on grammar achievement in AI-supported EFL contexts. Academic engagement operates as the driving mechanism of learning, AI literacy shapes the effectiveness of engagement processes, and task–assessment alignment determines whether these processes are validly captured in assessment outcomes. This mechanism–condition–constraint perspective provides a coherent explanation of learner variability and is supported by emerging empirical evidence, which indicates that academic engagement predicts grammar achievement, whereas completion-based AI platform behaviours may not provide additional explanatory power when task–assessment alignment is weak (Wang et al., in press).

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Conclusion

This review provides a theoretically integrated account of grammar achievement in AI-supported EFL contexts by synthesising research from language education, educational psychology, and AI-supported learning. Moving beyond descriptive summaries, the review addresses a central question: how learner-related factors shape grammar achievement in technology-mediated learning environments.

The findings support a mechanism–condition–constraint framework for understanding grammar achievement. Within this framework, academic engagement functions as the proximal learning mechanism, AI literacy operates as the enabling condition, and task–assessment alignment serves as the validity constraint. This framework provides a theoretically coherent lens for explaining how learner-related factors interact in AI-supported EFL contexts, while also highlighting the importance of alignment between learning processes and assessment practices. Future empirical studies are needed to validate the proposed framework and examine the relative contributions of its components.

By integrating these three dimensions, this review advances existing research in two ways. Theoretically, it reconceptualises grammar achievement as the outcome of interacting mechanisms rather than as a direct result of technological affordances or isolated learner variables. Methodologically, it highlights the importance of considering validity and alignment when interpreting platform-generated learning indicators, thereby addressing a critical limitation in current learning analytics research.

From a practical perspective, the findings suggest that improving grammar achievement in AI-supported environments requires coordinated instructional design rather than reliance on technology alone. Specifically, three design principles emerge: (1) engagement-driven task design, which promotes sustained and meaningful interaction with grammatical forms; (2) AI literacy scaffolding, which supports learners in interpreting and using AI-generated feedback effectively; and (3) alignment-oriented assessment design, which ensures consistency between learning activities, platform-generated indicators, and assessment tasks.

Finally, this review identifies several directions for future research. Further studies should examine grammar achievement as a distinct outcome in AI-supported learning, investigate the longitudinal development of engagement and AI literacy, and explore how instructional interventions can strengthen their interaction. In addition, more research is needed to examine how task–assessment alignment can be operationalised and measured in AI-supported environments. Addressing these issues can inform more coherent policy, pedagogy, and AI integration strategies by ensuring that AI-supported grammar learning is not judged by technology use alone, but by meaningful engagement, learner AI literacy, and assessment-valid evidence of learning.

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