

Exploring Student Engagement in a Multiple-Interaction Environment: GAI, Peer, and Teacher Feedback in L2 Writing from an Ecological Perspective

Yunuo Zhang¹ & Penghui Bi¹

¹ School of Foreign Studies, Yanshan University, China

Correspondence: Penghui Bi, School of Foreign Studies, Yanshan University, Qinhuangdao, Hebei, China. E-mail: youandbi@163.com

Received: November 6, 2025; Accepted: November 15, 2025; Published: November 16, 2025

Abstract

Over the past decade, scholarly attention to how learners engage with feedback significantly grown within Second Language Acquisition (SLA) research. However, few studies have examined learner engagement with feedback in a multiple-interaction environment composed of generative artificial intelligence (GAI), peer, and teacher feedback. Grounded in the ecological affordance theory, the present study investigates the feedback engagement of eight non-English major undergraduates in a multiple-interaction environment within an EFL writing context. This study was carried out by analyzing written texts, questionnaires, stimulated recall interviews, and semi-structured interviews, with an emphasis on the behavioral, affective, and cognitive aspects of engagement. The findings reveal: (1) Three types of learner feedback engagement were identified: peer-teacher oriented type, GAI-teacher oriented type, and GAI-peer-teacher oriented type; (2) While correlations exist among the three dimensions of feedback engagement, discrepancies between cognitive engagement and affective or behavioral engagement were observed, particularly in GAI feedback stage; (3) GAI's continuous mediation in some learners' writing revision processes significantly influenced their engagement with the other two sources of feedback. These results offer both theoretical and practical implications for fostering students' feedback literacy within intelligent education contexts and optimizing the design of multi-source feedback systems.

Keywords: multiple-interaction environment, feedback engagement, Second Language Writing, ecological perspective

1. Introduction

Written feedback (WF) is defined as a process through which learners interpret information from various sources and apply it to improve their work or learning strategies. In the context of writing, feedback conveys readers' perceptions and evaluations of a text, fosters the development of writers' cognitive abilities, encourages reflection on strengths and weaknesses, and thus supports the internalization of disciplinary knowledge and writing conventions (Hyland, 2013). In recent years, there has been an increasing academic focus in higher education on student engagement with WF (e.g., Han & Hyland, 2015; Xu & Long, 2022; Long & Qiu, 2024). This signifies a change in viewpoint—shifting from perceiving feedback as a fixed outcome to recognizing it as a dynamic process whose effectiveness is contingent upon learners' interactions with and reactions to it. Feedback engagement encompasses the cognitive, affective, and behavioral responses exhibited by learners following feedback receipt. Examining these responses provides insights into how learning opportunities emerge within the feedback process and offers a basis for targeted pedagogical interventions, thereby improving feedback uptake and maximizing its potential to support learning (Zhang & Hyland, 2018).

However, existing studies have largely focused on learner engagement with a single feedback source (e.g., teacher or peer feedback) and have rarely examined, from a multidimensional perspective, how learners engage in complex settings where they interact with multiple feedback sources such as generative artificial intelligence (GAI), peers, and teachers—that is, in so-called “multiple-interaction environments” (Xu & Long, 2022). Given that today's university EFL learners often receive input from different feedback sources simultaneously during the writing process, focusing on only one source is unlikely to reveal how multiple types of feedback work together to support the development of learners' writing proficiency. To address this gap, the present study adopts behavioral, cognitive, and affective dimensions to investigate the characteristics and patterns of EFL learners' feedback engagement in a multiple-interaction environment.

2. Literature Review

2.1 *The Concept of Learner Engagement with Feedback*

Learner engagement, as an important topic in educational research, initially drew the attention of researchers due to the widespread student boredom and high dropout rates in schools. It gradually focused on exploring how classroom teaching and task design, as well as the interaction between context and individuals, influence student engagement. Later, Fredricks et al. (2004) conceptualized engagement as the degree of learners' commitment or investment in their educational experiences, emphasizing its dynamic and multi-faceted nature. Engagement, as they define it, comprises three primary dimensions: affective, behavioral, and cognitive. Affective engagement involves learners' affective responses in educational environments, including feelings of joy, curiosity, sadness, anxiety, and boredom; behavioral engagement denotes students' constructive conduct within classroom and school settings, absence of disruptive behaviors, and involvement in academic tasks and activities; cognitive engagement pertains to students' mental commitment and use of effective learning strategies throughout the learning experience. Consequently, conceptualizing engagement as a multi-faceted construct enables a timely and dynamic investigation of the antecedents and outcomes across its three dimensions, as well as an analysis of their interactive effects.

The concept of "engagement with feedback" was initially proposed by Hyland (2003), emphasizing students' particular approaches to responding to teachers' form-focused feedback, including their revision practices and success rate, as well as variations among students in how they used feedback and the underlying factors. Handley et al. (2011) further expanded the notion by defining positive engagement with feedback in terms of two phases: readiness-to-engage and active engagement. This distinction not only enriches the connotation of "feedback engagement" but also highlights its progressive development process from psychological willingness to actual action.

Ellis (2010) introduced a three-dimensional model of engagement within the study of corrective feedback (CF) in oral and written second language acquisition, thereby refining the conceptual understanding of engagement in relation to feedback. He defined engagement as learners' responses to feedback, which can be observed from whether and how learners adopt CF, how they pay attention to CF, and how they emotionally respond to CF. Furthermore, Ellis pointed out that feedback types, individual factors, and contextual variables would jointly affect learners' feedback engagement. On this basis, Han and Hyland (2015) and Zhang and Hyland (2018) made more detailed adjustments to Ellis's three-dimensional framework and proposed a multi-dimensional framework for learners' interaction with WF. Informed by these studies (Han & Hyland, 2015; Fan & Xu, 2020; Zhang & Hyland, 2018), and aligning with the characteristics of this study, the current research adopts the widely cited framework in contemporary studies (e.g., Xu & Long, 2022; Long & Qiu, 2024). This framework categorizes EFL learners' engagement across feedback sources into three interconnected dimensions: (1) Behavioral engagement encompasses students' revision operations, including the uptake of feedback, revision actions, and the use of observable strategies; (2) Cognitive engagement refers to students' deliberate use of feedback through the application of both cognitive and meta-cognitive strategies; (3) Affective engagement involves students' interest in feedback, their value recognition of it, and their affective responses.

2.2 *Research on Learner Engagement with Feedback in L2 Writing*

Prior research on second language writing feedback has primarily examined learner engagement and its determinants from the standpoint of individual feedback sources, such as teacher, peer or automatic feedback. Evidence indicates considerable variation among learners in their engagement with feedback (Hyland, 2003; Han & Hyland, 2015), with these variations largely attributable to two categories of factors: individual and contextual. Han and Hyland (2015) found that L2 writers' revisions, cognitive and meta-cognitive operations, and affective responses when receiving teacher feedback were influenced by their learner beliefs, goals, and writing proficiency. The study by Zheng and Yu (2018) supports this finding: for lower-proficiency English majors, although they showed positive affective engagement, their limited language proficiency constrained their understanding of WF, as well as their use of cognitive and meta-cognitive strategies. A similar pattern was observed in the study by Yan and Zhang (2024), which examined L2 writers' interactions with ChatGPT-generated automated written corrective feedback. The findings revealed that four students with varying language proficiency levels demonstrated relatively active behavioral engagement, while only high-proficiency students were able to employ meta-cognitive strategies effectively. From a contextual perspective, Handley et al. (2011) noted that repeated experiences of assessment and feedback could influence learners' engagement, suggesting that engagement with feedback may vary across different times and contexts. Other studies have also shown that peer relationships, peer interaction patterns (Qian & Li, 2023), and teacher-student interactions (Zheng et al., 2023) can elicit either positive or

resistant emotions, thereby mediating learners' writing competence. While these studies clarify the conditions and factors influencing learner responses to feedback, they are typically confined to single-source contexts. In reality, learners often receive and actively seek feedback from multiple sources (Boud & Molloy, 2013). Therefore, examining effective approaches in multi-source feedback contexts is essential to improving feedback engagement and promoting favorable learning outcomes.

In addition to research on learner interaction with a single feedback source, scholars have also compared teacher feedback, automated feedback, and peer feedback. Dressler et al. (2019) investigated graduate students' uptake of peer and teacher feedback in an online research course, revealing a slight preference for adopting teacher feedback, which was also perceived as more valuable. Lai (2010) discovered that when both automated feedback and peer feedback were provided concurrently, undergraduate EFL learners utilized peer feedback more frequently, assigned it higher significance and perceiving automated feedback as comparatively imprecise. Huang and Teng (2025) further compared ChatGPT-generated feedback with peer feedback, examining their effects on Japanese EFL learners' affective, behavioral, and cognitive engagement in L2 writing. Their findings showed that ChatGPT feedback significantly enhanced students' affective and behavioral engagement, while no significant difference was observed in cognitive engagement compared with peer feedback. Overall, while comparative studies reveal differences in learner feedback utilization, their predominant focus on comparing two sources might overlook individual preferences and synergistic potential, resulting in a fragmented understanding. Consequently, research should systematically examine feedback engagement patterns in authentic environments where multiple sources interact.

Recent studies have begun to incorporate multiple feedback sources within a single research framework. Tian and Zhou (2020) examined five learners' engagement with automated, peer, and teacher feedback in an online tertiary-level English writing course. Their results revealed that engagement was dynamic and interactive across tasks, influenced by both contextual and individual factors. Xu and Long (2022) additionally observed that learners exhibited varying degrees of engagement across feedback sources, with a majority demonstrating distinct preferences for particular sources. By contrast, Zhang and Hyland (2022) reported that in a multiple-interaction environment, most learners demonstrated positive engagement across behavioral, affective, and cognitive dimensions. In addition, learners' engagement with multiple feedback sources has been shown to change over time and vary by task type. For example, Long and Qiu (2024) observed that students' engagement across feedback sources has transitioned from a dual-feedback orientation to a tri-feedback orientation, while Shi (2021) found that the type of writing task influenced learners' attitudes toward different feedback, with some students showing cognitive acceptance but delayed behavioral uptake. These studies offer significant understanding of feedback engagement in a multiple-interaction environment; however, a systematic exploration of the mechanisms underlying multi-source feedback synergy is still lacking.

2.3 AWE, DeepSeek and Generative AI in Second Language Learning

With the deepening application of information technology in education, Automated Writing Evaluation (AWE) systems, as a new type of feedback tool, have demonstrated significant value in L2 writing instruction (Zheng et al., 2021). Research has shown that such systems can effectively encourage learners to participate more actively in the revision process (Grimes & Warschauer, 2010). For example, Grammarly's real-time grammar detection and correction functions can help learners dynamically refine their language expression, enabling continuous improvement throughout the writing process (Thi et al., 2022). However, the actual effectiveness of AWE systems still faces multiple challenges. Bai and Hu's (2017) study revealed that current systems perform reasonably well in identifying surface-level issues such as grammar but provide notably insufficient feedback on content logic and discourse structure. In addition, Rupp et al. (2019) emphasized that developing AWE systems adaptable to diverse instructional contexts require considerable time and resources, with limitations becoming particularly apparent in complex writing tasks. These findings suggest that the technical bottlenecks of AWE urgently need to be addressed.

The official launch of ChatGPT in late 2022 marked a new stage in the technological evolution of education, showcasing transformative potential in foreign language teaching research, classroom instruction, and language learning (Barrot, 2023a). Trained on vast textual datasets, these models acquire the ability to analyze language patterns and generate highly human-like natural language output (Devlin et al., 2018). Compared with traditional AWE systems, GAI has a core advantage in supporting natural language dialogue: students can directly express their needs in everyday language (e.g., "Please check whether the academic wording in my paper is appropriate"), and the system can generate personalized feedback (Kasneji et al., 2023). By refining prompt design, teachers can quickly customize evaluation criteria to match different instructional stages, for example, basic grammar checks for beginners or academic expression enhancement for advanced learners.

With the breakthrough development of GAI technologies, intelligent feedback systems represented by DeepSeek are reshaping L2 writing instruction. DeepSeek-R1, launched in January 2025, has generated notable industry interest due to its promising performance in educational contexts. Chen and Hu (2025) conducted a comprehensive evaluation of DeepSeek's application potential in educational assessment from three dimensions: inter-rater reliability, rating stability, and feasibility. The research findings indicate that DeepSeek's scoring results demonstrate a high correlation with expert evaluations, consistent reliability performance, and significant advantages in efficiency and cost control, thereby substantiating the promotional value in educational assessment scenarios. In the field of second language writing, Gao et al. (2025) conducted a systematic evaluation of the reliability of the DeepSeek-R1 model in scoring and providing feedback on EFL learners' essays through G-theory and qualitative feedback analysis. Comparing the feedback from R1 with that from four university English teachers, this study showed that the scoring reliability of DeepSeek-R1 and the relevance of its feedback in dimensions such as content and structure were superior to those of the teachers, providing empirical support for its application in EFL teaching. Consequently, based on the evaluation results of the DeepSeek-R1's reliability from existing research, and taking into comprehensive consideration the operational feasibility of the study—given that DeepSeek-R1, as a GAI tool developed domestically in China, imposes fewer restrictions on learner access and facilitates smoother language communication—this study has decided to primarily provide learners with GAI support and relevant training centered around the DeepSeek-R1 system.

To conclude, current research on engagement with feedback in L2 writing has achieved two notable contributions: first, the establishment of behavioral, cognitive, and affective dimensions as a core analytical framework; second, a growing focus on the influence of multiple-interaction environments. However, significant research gaps persist. Current studies have yet to thoroughly investigate how L2 learners differentially utilize various feedback sources (e.g., teachers, peers, and GAI), nor have they explicitly elucidated the interplay among behavioral, cognitive, and affective dimensions in mixed feedback contexts. Particularly noteworthy is the emerging role of GAI as a feedback source, whose impact remains underexplored. Although some studies have begun to examine the interaction between GAI and L2 learners (e.g., Yan & Zhang, 2024), these investigations primarily treat GAI as an isolated or comparative feedback source. Accordingly, this study seeks to investigate how students interact with and react to GAI, peer and teacher feedback in real-world writing settings, emphasizing an analysis of how the integrated use of these feedback sources systematically shapes their multifaceted engagement processes.

3. Methods

3.1 Participants

The participants for this study consisted of first-year undergraduate students majoring in Applied Physics, Chinese Language and Literature, and Robot Engineering at a Chinese university, who were taught by a same English teacher in an English Reading and Writing course during their second semester. To ensure the diversity and informational richness of the sample, this study employed purposive sampling to select eight students for follow-up interviews based on three criteria: gender balance, CET-4 writing performance (high, medium, low), and academic background (liberal arts, science, engineering) (see Table 1). The average CET-4 score of all participants was above 525. Prior to their involvement in the study, each participant had signed an informed consent form and was assured that all research data would undergo anonymization procedures.

Table 1. Information about the participants

| Participants | Gender | Age | Major | CET-4 score | CET-4 score in writing | L2 Writing proficiency | GAI tool used |
|--------------|--------|-----|-------|-------------|------------------------|------------------------|-------------------|
| S1 | F | 19 | AP | 524 | 157 | medium | DeepSeek |
| S2 | F | 19 | AP | 536 | 155 | medium | DeepSeek |
| S3 | F | 18 | AP | 587 | 184 | high | Kimi |
| S4 | M | 19 | CLL | 467 | 139 | low | DeepSeek |
| S5 | F | 19 | CLL | 569 | 189 | high | DeepSeek & Doubao |
| S6 | M | 19 | CLL | 429 | 132 | low | DeepSeek |
| S7 | F | 18 | RE | 527 | 154 | medium | DeepSeek |
| S8 | M | 19 | RE | 457 | 140 | low | DeepSeek & Kimi |

3.2 Instruments

Informed by the learner engagement framework and recent studies (e.g., Han & Hyland, 2015; Fan & Xu, 2020; Zhang & Hyland, 2018), the study contends that students' behavioral, affective, and cognitive engagement with feedback can be investigated through analysis of textual revisions, questionnaires, and stimulated recall interviews.

Affective engagement in this study was measured using a 36-item questionnaire (see Appendix A), adapted from the affective engagement scales developed by Tsui and Ng (2000) and Fan and Xu (2020), which were originally designed to examine learners' affective engagement during peer feedback. The questionnaire was contextually modified in alignment with the research objectives, which encompasses dimensions such as perceived value of feedback, willingness to accept feedback, and emotional experiences during the feedback process. To align with the multiple-interaction environment of this study, items were modified to better capture students' experiences when receiving feedback from GAI, peers, and teacher. The survey utilized a five-point Likert scale (ranging from 1 = strongly disagree to 5 = strongly agree) to assess the three dimensions. Although the original scales have demonstrated satisfactory reliability and validity, to ensure the quality of the questionnaire, we invited three experts to evaluate and optimize its content, and conducted a pilot test involving 15 students. The results indicated a Cronbach's alpha coefficient of 0.81, suggesting good internal consistency reliability. Given that this study is an in-depth qualitative case study with a formal sample size of eight participants, the reliability was not re-examined in the formal study. However, the pilot test results have provided substantial support for the questionnaire's reliability. Furthermore, to enhance comprehension and accuracy in responses, the questionnaire was administered in Chinese and completion time averaged approximately 5 minutes.

Following each round of feedback, a stimulated recall interview was conducted, which spanned between 30 and 40 minutes. These interviews aimed to explore participants' perceptions of the different feedback sources, how they utilized feedback for revision, and strategies employed to improve their writing. During the interview, participants had access to their own writing drafts and corresponding feedback annotations. The interview content was audio-recorded, and the procedure was conducted with prior consent from the participants, ensuring their full awareness of the intended use of the recordings.

The written materials consist of the 8 participants' initial drafts, feedback from GAI, feedback from peers, teacher feedback, as well as their three revised versions. The essay topic is closely aligned with the specified course textbook to ensure teaching consistency and improve students' writing skills.

3.3 Data Collection

The study first examines whether and how learners uptake feedback by comparing the feedback text with the revised text. Second, a questionnaire is administered to investigate participants' affective engagement after receiving each type of feedback (teacher, peer, and GAI). Following the analysis of feedback, revised texts, and questionnaire outcomes, stimulated recall interviews are carried out to examine learners' observable revision behaviors, the cognitive and meta-cognitive strategies they employ upon receiving feedback, along with their emotional responses and attitudes throughout the revision process. Subsequently, semi-structured interviews are carried out following the final draft to obtain more in-depth understanding of learning experiences, goals, academic aspirations, and overall perceptions of the writing task (see Table 2 for the conceptual framework of feedback engagement and data collection).

Table 2. The conceptual framework of feedback engagement and data collection

| Dimensions | Sub-dimensions | Instruments |
|-----------------------|---------------------------|--|
| Behavioral engagement | Feedback uptake | Written texts |
| | Revision actions | |
| | Observable strategies | |
| Cognitive engagement | Cognitive strategies | Stimulated recall interviews |
| | Meta-cognitive strategies | |
| Affective engagement | Interest | Questionnaire & Stimulated recall interviews |
| | Affect | |
| | Value | |

3.4 Procedures

Following the study's commencement, students received a brief training session on using GAI tools, covering platform operations and the application of prompts. These prompts were designed to guide learners in obtaining feedback on essay structure, organization, coherence, and content completeness. Students then uploaded their initial drafts to the DeepSeek platform and refined their writing based on the AI-generated feedback. Subsequently, they submitted second drafts to peers for feedback. Prior to peer review, students underwent brief training aligned with the design principles of DeepSeek's prompts, focusing on foundational feedback techniques—particularly how to provide constructive criticism regarding writing structure, logical coherence, and content integrity. To facilitate peer assessment, the teacher allowed students to pair up and choose their own partners. Peer evaluations were conducted outside class hours to accommodate flexible scheduling, with feedback comments annotated directly on the writing drafts to inform the second round of revisions. Lastly, students submitted their third drafts, receiving written feedback from the teacher to guide further revision. For the fourth draft, the teacher assigned only a numerical grade as the conclusive evaluation of the students' writing performance.

3.5 Data Analysis

In this study, learners' correct revisions based on feedback are coded as successful uptake, while incorrect or inappropriate revisions are coded as unsuccessful uptake, and ignoring feedback is coded as non-uptake (Niu et al., 2021). Drawing on the revision taxonomy of Yang and Meng (2013) and the classification of revision operations by Zhang and Hyland (2018), and adapting them to the research context, revisions in students' drafts are coded as: addition, deletion, substitution, reorganization, rewriting, self-revision, and GAI-stimulated self-revision (see Table 3). Feedback uptake and revision actions are primarily examined through quantitative data analysis.

Based on the interview data, the researchers first coded the data from three perspectives—observable revision strategies, cognitive strategies, and meta-cognitive strategies—to investigate learners' engagement with multiple feedback sources. A questionnaire was then administered to examine learners' affective engagement after receiving feedback from different sources. The questionnaire results supplement the affective aspects identified in the interviews and inform the subsequent classification of feedback engagement types.

Finally, through repeated within-case and cross-case comparisons, the study identifies learners' engagement patterns with the three feedback sources. During the phase of text and interview data analysis, to ensure coding reliability, two researchers independently coded 30% of the text data and 15% of the interview data. The results demonstrated inter-coder agreement coefficients of 95%, 90%, 91%, 87%, and 88% across the five dimensions of feedback uptake, revision actions, observable strategies, cognitive strategies, and meta-cognitive strategies respectively, indicating a high level of reliability in the coding system. The remaining data were coded and analyzed independently by the first author.

Given the potential inconsistency among dimensions of feedback engagement (Fan & Xu, 2020; Xu & Long, 2022), active engagement in this study is defined as strong performance in at least two dimensions. Based on this definition, learners' engagement with feedback from GAI, peers, and the teacher is identified, and the types and inherent tensions of feedback engagement in a multiple-interaction environment are described in depth.

Table 3. The framework of revision actions

| Categories | Definitions |
|------------------------------|--|
| Addition | To add the new content to the original text based on feedback, |
| Deletion | To reduce sentences, phrases, paragraphs, etc. based on feedback. |
| Substitution | To replace the inadequate words, phrases, sentences or paragraphs based on feedback. |
| Reorganization | To adjust the order or structure between sentences or paragraphs based on feedback. |
| Rewriting | To rewrite the original sentence or paragraph based on feedback. |
| Self-revision | To spontaneously modify the text in the absence of feedback regarding deficiencies. |
| GAI-stimulated self-revision | To spontaneously modify the text based on the information provided by GAI in the absence of feedback regarding deficiencies. |

4. Results

Based on the analysis of written texts and interview data, the feedback engagement of the eight participants was categorized into three types: GAI-teacher oriented type (S2, S6), peer-teacher oriented type (S5), and GAI-peer-teacher oriented type (S1, S3, S4, S7, S8). This study adopts the definition proposed by Xu and Long (2022), where “active engagement” is characterized by satisfactory performance in at least two of the three dimensions: behavioral, affective, and cognitive. Overall, all learners demonstrated high levels of engagement across the three dimensions, yet exhibited distinct preferences for feedback sources and interaction patterns. Given the noted consistency in performance across participants within each category, this study selected one representative from each group (S2, S5, S8) for detailed examination.

4.1 GAI-Teacher Oriented Type

From the affective perspective, S2 demonstrated an exceptionally positive experience with the GAI-assisted essay revision process. Following the initial round of essay revisions, S2 perceived DeepSeek as a personalized vocabulary coach characterized by “high efficiency and accuracy.” She noted that since starting university, reduced English study time and weak self-motivation had eroded her CET-4 vocabulary. In the process of interacting with DeepSeek, S2 found that GAI helped her reactivate forgotten vocabulary and counter language attrition. She particularly valued the “sustained inquiry” function, which allowed her to refine prompts for more level-appropriate suggestions, thus avoiding information overload. This interaction also reduced the anxiety of face-to-face communication and saved significant consultation time. The survey results (with mean scores of 4 for both affect and value, and 3.75 for interest) substantiate S2’s positive affective engagement with GAI feedback.

However, S2 questioned the authenticity of peer feedback and even the necessity of peer assessment itself. She pointed out that most of her classmates would use GAI when reviewing others’ essays. Therefore, although she received a lot of positive feedback and felt “recognized by her peer,” she still inevitably questioned whether these comments genuinely originated from her classmate, thinking that he “did not put much effort into it.” Ultimately, she concluded that the form of peer review had limited value, candidly stating that “it would be more straightforward and effective to simply use AI to review my essay again.” The questionnaire results (with mean scores of 3.25 for affect, 3 for interest, and 2.75 for value) further support S2’s relatively low affective engagement with peer feedback.

Among these three sources of feedback, S2’s affective engagement in teacher feedback was the most prominent. She believed that the teacher possessed greater professional expertise and more extensive experience compared to peers of similar proficiency levels. The suggestions provided by the teacher were deemed more constructive and manageable, which effectively prevented her from feeling unduly overwhelmed. Additionally, she stressed the authentic care conveyed through the teacher’s comments, observing that they were “clearly not automated and reflected genuine dedication.” This experience of receiving attentive guidance significantly enhanced her motivation for writing. The survey results, with mean scores of 4.5 for both affect and interest, and 4 for value, corroborate S2’s positive affective engagement with teacher feedback.

In terms of behavioral engagement, S2’s successful uptake rates for GAI (88.2%), peers (100%), and teachers (87.5%) all remained at a relatively high level. However, there is a significant contradiction between this behavioral data and her emotional attitude: she has the lowest affective responses of peer feedback, but her uptake rate is the highest. This inconsistency may be attributed to the limited quantity of peer feedback received, which predominantly involved superficial lexical modifications. Such feedback is highly actionable, but simultaneously it reinforces S2’s negative value recognition that peer feedback “lacks depth and conscientious engagement.”

An analysis of revision actions shows that S2 employed multiple strategies—including substitution, addition, deletion, rewriting, and GAI-stimulated self-revision—when processing GAI feedback, and utilized substitution, addition, rewriting and reorganization for teacher feedback. This diversity in revision actions demonstrates her deep cognitive processing when dealing with these two feedback sources. However, when addressing peer feedback, S2’s revision actions appeared relatively simplistic, primarily focusing on superficial lexical or syntactic substitutions. Notably, after completing revisions based on peer feedback, three instances of “GAI-stimulated self-revision” emerged in the text. In the subsequent interview, S2 elaborated that these modifications represented further revision she implemented using DeepSeek. This behavior demonstrated that when peer feedback lacked sufficient inspiration, S2 proactively integrated resources and seeks in-depth support from higher-quality feedback sources (GAI), thereby achieving a transition from superficial revisions to profound optimization.

From the perspective of observable strategies, S2 primarily employed three strategies during the GAI revision phase: utilizing translation software to check unfamiliar vocabulary, engaging in secondary interaction with DeepSeek, and composing reflective journals to systematically analyze deficiencies in her writing and assimilate

insights provided by GAI. When processing peer feedback, S2 adopted a relatively direct approach, limiting her revisions to correcting errors identified by the peer without further documenting them in notebooks. She also mentioned, when uncertainties arose regarding peer feedback, she tended to seek explanations from DeepSeek rather than engaging in further discussions with classmates. In addressing teacher feedback, S2 reported not utilizing any auxiliary tools but instead making revisions directly based on the teacher's annotations. She explained this by expressing complete trust in the teacher's feedback, viewing it as an authoritative reference. After completing revisions, she consciously documented practical phrases from the teacher's annotations in her notebook to reinforce retention and accumulation.

Cognitively, S2's high uptake of GAI and teacher feedback does not stem from passive acceptance but rather involves profound cognitive processing. She particularly emphasized analyzing whether the feedback aligned with her writing style and expressive intentions. For instance, in terms of word choice, she evaluated DeepSeek's recommendation of "participate in" as relatively generic, while her own use of "throw into" conveyed greater dynamism and personal flair, thus consciously deciding to retain her original expression. During the revision process, S2 deliberately connected the sentence structures and vocabulary taught in class with GAI and teacher feedback, thereby achieving effective knowledge transfer and deeper comprehension. Furthermore, after each revision, S2 summarized and accumulated valuable expressions learned from DeepSeek and teacher feedback, continuously building a repository of linguistic resources for her future English writing endeavors. Consequently, when revising teacher and peer feedback, S2 predominantly employed cognitive strategies such as analysis, evaluation, connection, and summarization.

S2's approach to processing peer feedback exemplifies a meticulous cognitive processing mechanism. Rather than mechanically adopting or intuitively judging the feedback, she first employed DeepSeek to conduct cross-validation of the peer feedback to ensure the reliability of the revisions. Subsequently, after completing the initial revisions based on peer feedback, she proactively sought secondary interaction with GAI, upon which she made more profound adjustments and optimizations to the content and logic of the article. In summary, throughout this process, S2 primarily utilized cognitive strategies such as cross-validation, evaluation, and iterative optimization.

The revision process of S2 primarily reflected the meta-cognitive strategy of process-mapping. She initially evaluated the value of various feedback sources, determining that GAI could provide extensive informational references, while teacher feedback was the most authoritative and targeted. Based on this assessment, she deliberately planned her revision workflow, deciding to allocate most of her time and effort to processing GAI and teacher feedback to maximize learning efficiency. In comparing GAI and teacher feedback, S2 found that peer feedback offered relatively limited depth and specificity, thus regarding it as a secondary feedback source and accordingly reducing her level of engagement with it.

4.2 Peer-Teacher Oriented Type

S5 exhibited limited engagement with GAI at the affective level. In the GAI text revision process, S5 utilized both DeepSeek and Doubao in an alternating manner. Initially, she held high expectations for both tools based on peer recommendations. However, after practical application, she concluded that neither tool delivered satisfactory results. Her main critique targeted Doubao's frequent misalignment with her writing intentions. Regarding DeepSeek, she acknowledged its slight edge in emotional expression but criticized its formulaic sentence restructuring, which piled up complex syntax and compromised naturalness. The survey results indicate that S5 scored an average of 3.25 in both affect and value, and 3.75 in interest, which are comparatively lower than those of S2. This suggests a relatively lower affective engagement of S5 in response to GAI feedback.

S5 believed that peers were more meticulous in handling details than GAI. She pointed out that even after GAI's first round of revisions, the classmate could still spot many grammar errors that the GAI failed to identify. Regarding the situation where peers sometimes failed to understand her writing intentions, S5 was tolerant, considering it a reasonable cognitive difference. From her point of view, peer review was not only an effective communication activity but also a fun learning process. The survey results indicate that S5 scored an average of 4 for all aspects, which suggests her positive affective engagement in response to peer feedback.

Similar to S2, S5 regarded teacher feedback as the most authoritative guidance. She noted that in daily writing practice, she placed greater emphasis on expressing her personal style. She believed the teacher's guidance aligns perfectly with this need—the teacher not only refrained from undermining her writing style but also refined her language with greater nuance. Moreover, the teacher provided a systematic perspective that helped her organize and strengthen the logical coherence of her writing and such comprehensiveness is difficult to match with other sources of feedback. The survey results indicate that S5 scored an average of 5 in both interest and value, and 4.5 in affect, which can suggest the highest affective engagement into teacher feedback.

At the level of behavioral engagement, the successful uptake rate of S5 for GAI feedback (43%) was significantly lower compared to teacher feedback (91%) and peer feedback (75%), with a notably higher non-uptake rate (31%). This suggests that S5's low affective engagement with GAI feedback may contribute to the reduced uptake rate. In terms of revision actions, S5 demonstrated the deepest cognitive processing in response to teacher feedback, as evidenced by her application of the most diverse revision strategies (primarily "rewriting"), including rewriting, reorganizing, substitution, and addition. In contrast, although S5's emotional evaluation of peer feedback was higher than that of GAI feedback, the revision strategies she employed (substitution, adding) did not show significant differences when processing these two types of feedback.

As for observable strategies, upon receiving GAI feedback, S5 did not engage in secondary interaction with DeepSeek or Doubao but relied on translation software to resolve lexical and syntactic uncertainties. She emphasized prioritizing the practical utility of vocabulary over its complexity, noting that DeepSeek provided less comprehensive grammatical information, such as parts of speech, compared to specialized translation tools. When addressing peer feedback, beyond consulting translation software for unfamiliar terms, she responded to the comments from her peer and engaged in discussions with her classmate regarding resonance and discrepancies in the essay. For instance, a peer's comment that she "skillfully employed" emphatic sentences prompted her to express particular interest in obtaining broader peer evaluations of her essay. S5 regarded teacher feedback as a pivotal component, recognizing its efficacy in resolving ambiguities previously left unaddressed by GAI and peer feedback. Consequently, during this phase, she comprehensively reviewed the essay. To enhance the final maturity of the essay, S5 employed multiple strategies: she utilized electronic dictionaries to verify spelling accuracy, leveraged sentence analysis features in translation software for grammatical corrections, optimized content through the integration of online resources, and after the revision was completed, the concise expressions provided by the teacher would be systematically organized in the notes.

The cognitive engagement exhibited by S5 in response to GAI feedback was unexpectedly profound. When processing GAI feedback that she did not fully endorse, S5 demonstrated a deeper cognitive processing mechanism, specifically manifested through a series of cognitive strategies such as comparison, analysis, summarization, and memorization. Firstly, rather than passively accepting feedback from a single source, she actively compared the outputs of DeepSeek and Doubao line by line, identifying that DeepSeek exhibited superior performance in the naturalness of emotional expression and logical coherence, whereas Doubao's language appeared relatively rigid. Based on this observation, she opted to primarily adopt DeepSeek's suggestions, selectively referencing the valuable aspects of Doubao's feedback. In her detailed handling of DeepSeek's feedback, S5 further analyzed whether the sentence structures provided were overly complex and beyond her current writing proficiency, or whether the vocabulary used was contextually appropriate. After completing the revisions, she would summarize and memorize typical errors pointed out by GAI, such as the preference for "bridge the gap" over "remove the gap," to achieve knowledge consolidation and internalization. Notably, while S5 did not exhibit active engagement with GAI tools at the affective or behavioral level, she displayed characteristics of deep cognitive processing.

S5 employed cognitive strategies such as categorization, analysis, summarization, and root cause identification when processing feedback from the teacher and peers. Initially, she utilized different colored pens to categorize and annotate feedback types, enabling rapid identification of key areas for revision. Subsequently, she meticulously analyzed each comment from the teacher and the classmate, focusing not only on linguistic corrections but also on verifying whether her writing intentions were accurately comprehended. Building upon the integrated feedback, S5 proactively summarized recurring error patterns in her writing, focused on persistent fundamental errors that remained even after GAI revisions, which she documented in her notes to prevent recurrence. For complex issues, such as the grammatical point regarding the inappropriate use of "choosing" as an adverbial participle in her original sentence, as highlighted by both the teacher and the classmate, S5 conducted further online research for verification. She extended beyond mere error correction, delving into the cognitive origins of mistakes to thoroughly clarify long-standing misunderstanding, thereby achieving knowledge structure updating and consolidation.

From the perspective of meta-cognitive strategies, S5 primarily demonstrated strategies of needs-based positioning and goal-setting during the process of revising the essay. She possessed a clear understanding of her English proficiency level and the core issues in her writing, particularly the frequent occurrence of "Chinglish" expressions influenced by her academic background. Consequently, S5 placed significant emphasis on meticulously processing teacher feedback and has established specific objectives to enhance linguistic authenticity. She believed that, compared to GAI tools, professional English teachers can provide more authentic language demonstrations, thereby more effectively assisting her in overcoming Chinglish issues. Furthermore, during the GAI revision phase, S5 actively monitored the quality of the modifications throughout the process. She paid particular attention to the

whole quality of her essay: whether accepting GAI feedback would result in excessive verbosity in her essay, and whether GAI overusing sophisticated vocabulary and sentence structures might lead to reader fatigue. After implementing teacher feedback, S5 conducted multiple reviews of her essay to ensure all identified errors have been completely corrected. In summary, S5 has comprehensively applied a series of meta-cognitive strategies, including needs-based positioning, goal-setting, quality monitoring, and error monitoring, throughout her revision process.

4.3 GAI-Peer-Teacher Oriented Type

At the level of affective engagement, S8 expressed high regard for all the three feedback sources, acknowledging that these feedback respectively offered distinctive perspectives and established a complementary relationship. Specifically, he noted that DeepSeek provided comprehensive feedback, addressing not only surface-level errors such as spelling and pluralization but also offering suggestions on deeper writing techniques like argumentation and logical structure. S8 also highly appreciated DeepSeek's scoring and guidance features. He observed that by inputting crafted prompts, DeepSeek could generate a "relatively objective score" based on big data analysis, allowing him to clearly gauge "how far the current writing level is from the target score." Furthermore, he particularly highlighted the immense value of DeepSeek's post-assessment guidance, which enabled him to pinpoint the weakness and offered clear direction for subsequent targeted training. The survey results indicate that S8's mean affect score is 4, the mean interest score is 4.5, and the mean value score is 3.75. These figures numerically reflect the positive affective engagement of S8 in the GAI feedback.

Regarding peer feedback, he mentioned that the classmate was exceptionally meticulous in her evaluation, with neat handwriting and detailed comments, which deeply moved him. As for the possibility of the classmate utilizing GAI-assisted corrections, S8 indicated that he could discern and empathize with such instances, believing that "the classmates do not blindly rely on AI but instead meticulously filtered the information." and that "the procedure must require considerable time and effort," and ultimately yielded conclusions that were "even more convincing." The results of the questionnaire (with the average score of affect being 3.5, interest 4.5, and value 4) to some extent reflect S8's positive engagement in the feedback from peers.

Of the three feedback sources, S8 found teacher feedback to be particularly precise and in-depth, capable of "hitting the nail on the head" by resolving those tricky issues that remained uncertain after receiving feedback from both GAI and the classmate. S8 believed that compared to relying solely on a single feedback source, integrating multiple feedback sources significantly enhances learning outcomes. The model can provide "guidance from multiple angles," helping him to more comprehensively evaluate his writing. S8 also mentioned that repeated exposure to the same errors in different feedback sources deepens his impression of common writing errors, ensuring that key knowledge points are reinforced and thoroughly mastered. The survey results (with the average score of affect for S8 being 4 and the average scores of interest and value both being 4.75) could reflect the highest affective engagement of S8 in the teacher feedback.

Behaviorally, the feedback uptake of S8 across three feedback sources—GAI, peer, and teacher—demonstrated favorable outcomes, with successful uptake rates ranging from 81% to 93% and non-uptake rates maintained at a relatively low level of 0% to 12%. These data indicated that S8 effectively incorporated feedback from diverse sources at the uptake level. More significantly, this proactive behavioral uptake aligns closely with his previously demonstrated trust and openness toward multifaceted feedback, reflecting a consistent integration of affective and behavioral engagement. From the perspective of revision actions, S8 demonstrated a high level of revision activity across all three feedback sources, with "substitution" being the most frequently employed revision strategy in each round. Notably, following peer feedback, he utilized the most diverse range of revision strategies (including substitution, addition, deletion, reorganization, rewriting, and self-revision), suggesting that peer feedback may more effectively stimulate his deeper reflection on essay reconstruction.

As for observable strategies, S8 demonstrated the capability to flexibly adjust its revision strategies and tool combinations based on the characteristics of feedback sources, thereby maximizing resource utilization. In response to GAI feedback, he addressed structural concerns in essay through secondary interaction with DeepSeek, utilized the electronic dictionary to acquire new vocabularies which were subsequently recorded in his personal lexicon, and systematically summarized the inadequacy identified by GAI in his notebook. Regarding queries arising from peer and teacher feedback, his consultation scope extended more broadly, incorporating not only DeepSeek but also cross-verifying insights from alternative GAI tools such as Kimi, while actively engaging in face-to-face discussions with learning partners, recognizing that peer perspectives often provide crucial insights.

Regarding cognitive engagement, S8 predominantly utilized cognitive strategies including analysis, connection, and summarization when revising GAI feedback. He did not blindly accept GAI feedback but first assessed their

accuracy. For instance, when DeepSeek flagged the phrase “an amount of opportunities” as a collocation error and suggested changing it to “amounts of” (which modifies uncountable nouns), S8 questioned this feedback. He engaged in further interaction with DeepSeek and confirmed that the initial GAI suggestion was indeed incorrect. Even when feedback was verified as correct, S8 evaluated its practicality. If suggestions involve vocabulary beyond his current writing level, he may choose not to adopt them, fearing that “misspelling such words in exams could lead to penalties from graders.” When incorporating GAI feedback, S8 consciously connected it to knowledge points learned in class for verification and adjustment. After making revisions, he proactively summarized and accumulated useful sentence patterns and vocabulary provided by DeepSeek.

Similar to S2, when S8 harbored doubts or uncertainties regarding the content upon receiving feedback from peers, he initiated a secondary verification process utilizing DeepSeek. Concurrently, he emphasized the integration of peer and GAI suggestions for sentence revisions, synthesizing these inputs to refine and polish the final expression to his perceived optimal fluency. S8 acknowledged that “the teacher’s feedback is sufficiently authoritative,” thus refraining from employing GAI to assess its accuracy during revisions. However, he employed various GAI tools to deepen his comprehension of the knowledge points mentioned in the feedback, documenting the expanded content in his notebook. In summary, S8 employed a multifaceted approach to processing teacher and peer feedback, incorporating strategies such as cross-validation, synthesis, and restructuring of knowledge frameworks.

Multiple meta-cognitive strategies were employed by S8 during the revision process. Initially, he actively utilized planning strategies, as evidenced by his explicit formulation of learning goals for the semester. Recognizing his unsatisfactory performance in English during the first semester (receiving only a C grade), S8 set a specific goal to dedicate more effort to improving his English proficiency, particularly in writing, aiming to achieve an A grade. Based on this learning goal, he further planned to “utilize as many resources as possible” to support his learning, demonstrating strategic planning in accomplishing his tasks. Secondly, S8 exhibited distinct strategic awareness in planning his revision process. He recognized that “the teacher determines both the final draft and the course grade,” and observed that “the teacher, despite being extremely busy, pays meticulous attention to essay revisions.” Consequently, he consciously positioned teacher feedback as the central component of her revision process, investing substantial effort in repeatedly reviewing and refining his essay to prevent the recurrence of errors explicitly identified by the teacher. During the revision phase, S8 successfully implemented meta-cognitive strategies such as planning, goal-setting, process mapping, and error monitoring.

5. Discussion

This study reveals the complexity of the eight participants’ affective, behavioral, and cognitive engagement in a multiple-interaction environment, identifying three distinct oriented types. This finding echoes and deepens the research conclusion of Xu and Long (2022) that learners do not actively engage with all three feedback sources to an equal extent. Instead, they focus their engagement on two or three sources of feedback. Learners’ selective emphasis on different feedback sources can be robustly explained through the lens of ecological affordance theory. From an ecological perspective, the multiple-interaction environment comprising teacher, peers, and GAI inherently contains rich affordance potential (Zhang & Hyland, 2022). However, the transformation of these potentials into actual affordances is not automatic but hinges on a critical synergistic process: the alignment between learners’ individual needs, goals, and capabilities and the contextual factors (Long & Qiu, 2024). According to van Lier (2004), this transformation process relies on learners’ active “perception-interpretation-action” cycle. For instance, when S2 recognized the immediacy of DeepSeek feedback as significantly beneficial for enhancing writing and revision efficiency, she was inclined to exhibit proactive engagement with GAI. In this process, S2 could perceive the feedback source that exhibits a high degree of alignment with her current individual needs, thereby converting environmental potentials into actual affordances. Consequently, learners in the study might adjust the level and manner of their engagement based on their perception and interpretation of the ecological affordances provided by diverse feedback sources.

This study further confirms that the three dimensions of learner feedback engagement are interconnected in a multi-interaction environment, which is on par with the findings of Fan and Xu (2020) and Xu and Long (2022). Specifically, affective engagement, as a core driving force, can significantly influence learners’ engagement at both the behavioral and cognitive levels. For instance, S8’s affective responses and value recognition towards all feedback resources are directly reflected in his revision operations and cognitive processing strategies, demonstrating consistency across dimensions. Additionally, the study also supports Yu et al.’s (2019) findings that there may be inconsistencies among the three dimensions of feedback engagement. For example, S5 showed a clear contradiction between her cognitive and affective or behavioral engagement when processing GAI feedback. This discrepancy might stem from S5’s constrained perception of affordances from GAI feedback. As a highly proficient L2 learner, she can precisely perceive and deeply utilize the cognitive affordances offered by GAI in

terms of word choice, logical cohesion, and other cognitive aspects, which supports her high level of cognitive engagement. Affectively, however, S5 held a complex attitude towards GAI feedback, which might be due to the fact that the impersonal, algorithmically generated nature of GAI feedback was difficult to evoke her emotional resonance (Long & Qiu, 2024). Additionally, since S5 perceived GAI primarily as a functional tool for information extraction and problem-solving rather than as a medium for interpersonal exchange, she might acknowledge the instrumental value of GAI feedback for cognitive tasks, but this perception inherently limited her emotional connection to it. Consequently, S5's interpretation towards GAI feedback impacts her behavioral uptake and restricts the transformation of the affordance potentials.

Building on the notion of GAI as a “collaborative companion” (Koltovskaia et al., 2024), this study provides empirical evidence that for certain learners, GAI evolves from a phased tool into a key component integrated through the entire revision process. This deep embedding enables it to play a pivotal mediating role in a multiple-interaction environment, to a certain extent reshaping how learners perceive and engage with other feedback sources. Specifically, by leveraging GAI alongside other feedback sources, learners enhanced their cognitive processing of the feedback. For instance, as mentioned above, S2 utilized GAI to cross-validate peer feedback's accuracy, and subsequently sought its suggestions to refine the essay; S8 input the main points of teacher feedback into GAI, and instructed it to generate relevant examples, thereby deepening personal knowledge structures. These behaviors indicate that GAI's mediating role not only bridges different feedback sources but also activates and supports learners' cognitive activities of comparison, evaluation, and in-depth processing.

Nevertheless, the mediation of GAI might exhibit an adverse effect on learners' affective engagement in peer feedback processes. Specifically, when S2 identified that the comments in peer feedback appeared overly artificial, she was prone to form a low value judgment that “peer feedback can be replaced.” This reflects the disruptive challenge posed by GAI to the value of traditional interpersonal feedback, which aligns with the empirical findings of Huang & Teng (2025): GAI feedback may surpass traditional peer feedback in triggering learners' deep affective engagement. The underlying reason lies in the fact that learners' expectations for feedback have shifted from basic informational accuracy to higher-order demands for “deep personalization”—namely, the desire to receive feedback that is rooted in shared learning experiences, enriched with unique insights, and imbued with emotional understanding. This is a dimension that GAI struggles to fully replicate. When peer feedback remains at a superficial level that GAI can easily reproduce, it fails to meet these expectations, leading to a decline in learners' affective engagement.

It is noteworthy that in the multiple-interaction environment integrated with GAI, the teacher continues to occupy a pivotal role, as learners exhibit positive engagement across cognitive, behavioral, and affective domains, which corroborates the relevant discussions by Xu and Long (2022) and Zhang and Hyland (2022). Students generally concurred that “teacher feedback holds the highest authority,” emphasizing the necessity of the teacher's prompt training prior to the GAI-assisted revision and classroom guidance before peer reviews. This indicates that teachers who provide social support, such as providing problem-solving guidance, enhancing students' self-esteem and demonstrating various forms of resources, can significantly enhance student engagement and foster positive behaviors in the classroom (Jia & Cheng, 2024). Consequently, teachers are required to systematically optimize the feedback process and guide students in critically discerning and assimilating various forms of feedback. Specifically, it is imperative to establish explicit guidelines for the use of GAI tools at the onset of the course, delineating prohibited and encouraged application scenarios to lay the foundation for academic integrity. Furthermore, when organizing peer reviews, teachers should direct students to focus on each other's thought processes and revision methodologies rather than merely evaluating the final outcomes. Concurrently, students should be encouraged to integrate personal experiences with shared classroom contexts to provide more empathetic and contextually relevant feedback. By implementing these participatory learning methods, the ultimate goal is to stimulate students' learning autonomy and higher-order thinking (Prananto et al., 2025).

6. Conclusion

This study investigates the feedback engagement of eight Chinese EFL learners in a multiple-interaction environment. The findings firstly revealed that not all participants actively engaged with the three feedback sources. Instead, distinct patterns of preference were observed among these learners, which can be categorized into three orientations: GAI-teacher oriented type, peer-teacher oriented type, and GAI-peer-teacher oriented type. Secondly, significant correlations were identified between students' three dimensions of engagement across feedback sources, as S2's positive affective engagement in GAI feedback could influence her behavioral and cognitive engagement levels. Simultaneously, certain contradictions were observed among these engagement dimensions, as S5 exhibited negative affective responses and relatively insufficient behavioral engagement towards GAI feedback, yet rationally acknowledged its learning value at the cognitive level. Furthermore, the study found that GAI appeared

to mediate students' engagement with the other two feedback sources. This mediating effect manifested behaviorally through the integration of GAI throughout the entire revision cycle for some participants, and affectively through the influence of GAI on certain students' valuation of peer feedback.

However, this study still has several limitations. Firstly, in terms of the sample, the participants mainly came from the same university in China, resulting in a relatively single source, which may to some extent affect the generalizability of the research results. Secondly, the research period was relatively short, lacking longitudinal tracking of the dynamic evolution process of learners' feedback engagement. Finally, this study did not conduct a systematic and in-depth exploration of the multiple factors influencing feedback engagement. For instance, variables such as participants' previous experience and proficiency with GAI, and the quality differences of peer feedback were not considered, which could affect learners' engagement across various feedback sources.

In light of the limitations of this study and the context of integrating GAI as a novel feedback source into multiple-interaction environments, future research can be deepened and expanded in the following directions: in terms of research design, studies could focus on longitudinally tracking the dynamic evolution of learners' feedback engagement across feedback sources, thereby exploring the underlying individual and contextual factors. Regarding data collection methodologies, research could incorporate multi-modal data to more precisely and objectively measure engagement across various dimensions. For instance, eye-tracking and revision logs could be utilized to conduct in-depth analyses of learners' affective responses and revision behaviors. Finally, future research could particularly focus on the specific mechanisms of GAI in the multiple-interaction environment, through experiments and models to explore how GAI concretely mediates students' engagement in human interaction, thereby assisting educators in developing more effective "human-machine collaborative" teaching models.

Acknowledgments

The research is supported by the Research and Practice Project on English Teaching Reform in Higher Education Institutions of Hebei Province (No. 2024YYJG012), and the Teaching Research and Reform Project of Yanshan University (No. 2024XJJG134).

References

- Bai, L., & Hu, G. (2017). In the face of fallible AWE feedback: How do students respond? *Educational Psychology*, 37(1), 67-81. <https://doi.org/10.1080/01443410.2016.1223275>
- Barrot, J. S. (2023). Using ChatGPT for second language writing: Pitfall and potentials. *Assessing Writing*, 57, 100745. <https://doi.org/10.1016/j.asw.2023.100745>
- Boud, D., & Molloy, E. (2013). Rethinking models of feedback for learning: The challenge of design. *Assessment and Evaluation in Higher Education*, 38(6), 698-712. <https://doi.org/10.1080/02602938.2012.691462>
- Chen, X., & Hu, Z. (2025). Evaluating DeepSeek-Powered Intelligent Scoring: Validity, Reliability, and Feasibility. *Higher Education Exploration*, (03), 62-67.
- Devlin, J., Chang, M. W., Lee, K., & Toutanova, K. (2018). BERT: Pre-training of deep bidirectional transformers for language understanding. *ArXiv*. <https://doi.org/10.48550/arXiv.1810.04805>
- Dressler, R., Chu, M. W., Crossman, K., & Hilman, B. (2019). Quantity and quality of uptake: Examining surface and meaning level feedback provided by peers and an instructor in a graduate research course. *Assessing Writing*, 39, 14-24. <https://doi.org/10.1016/j.asw.2018.11.001>
- Ellis, R. (2010). A framework for investigating oral and written corrective feedback. *Studies in Second Language Acquisition*, 32(2), 335-349. <https://doi.org/10.1017/S0272263109990544>
- Fan, Y., & Xu, J. (2020). Exploring student engagement with peer feedback on L2 writing. *Journal of Second Language Writing*, (50):100775. <https://doi.org/10.1016/j.jslw.2020.100775>
- Fredricks, J., Blumenfeld, P., & Paris, A. (2004). School engagement: Potential of the concept, state of the evidence. *Review of Educational Research*, 74(1), 59-109. <https://psycnet.apa.org/doi/10.3102/00346543074001059>
- Gao, H., Hashim, H., & Md Yunus, M. (2025). Assessing the reliability and relevance of DeepSeek in EFL writing evaluation: a generalizability theory approach. *Lang Test Asia*, 15, 33. <https://doi.org/10.1186/s40468-025-00369-6>
- Grimes, D., & Warschauer, M. (2010). Utility in a fallible tool: A multi-site case study of automated writing evaluation. *The Journal of Technology, Learning and Assessment*, 8(6). Retrieved from <http://www.jtla.org>
- Han, Y., & Hyland, F. (2015). Exploring learner engagement with written corrective feedback in a Chinese tertiary

- EFL classroom. *Journal of Second Language Writing*, 30, 31-44. <https://doi.org/10.1016/j.jslw.2015.08.002>
- Handley, K., Price, M., & Millar, J. (2011). Beyond “doing time”: Investigating the concept of student engagement with feedback. *Oxford Review of Education*, 37(4), 543-560. <https://doi.org/10.1080/03054985.2011.604951>
- Huang, J., & Teng, M. F. (2025). Peer feedback and ChatGPT-generated feedback on Japanese EFL students' engagement in a foreign language writing context. *Digital Applied Linguistics*, 2, 102469. <https://doi.org/10.29140/dal.v2.102469>
- Hyland, F. (2003). Focusing on form: Student engagement with teacher feedback. *System*, 31(2), 217-230. [https://doi.org/10.1016/S0346-251X\(03\)00021-6](https://doi.org/10.1016/S0346-251X(03)00021-6)
- Hyland, K. (2013). Faculty feedback: Perceptions and practices in L2 disciplinary writing. *Journal of Second Language Writing*, 22(3), 240-253. <https://doi.org/10.1016/j.jslw.2013.03.003>
- Jia M, Cheng J. (2024). Effect of teacher social support on students' emotions and learning engagement: a U.S.-Chinese classroom investigation. *Humanit Social Sci Commun*, 11(1):1. <https://doi.org/10.1057/s41599-024-02634-0>
- Kasneci, E., Sessler, K., Küchemann, S., Bannert, M., Dementieva, D., Fischer, F., ... & Kasneci, G. (2023). ChatGPT for good? On opportunities and challenges of large language models for education. *Learning and Individual Differences*, 103, 102274. <https://doi.org/10.1016/j.lindif.2023.102274>
- Koltovskaia, S., Rahmati, P., & Saeli, H. (2024). Graduate students' use of ChatGPT for academic text revision: Behavioral, cognitive, and affective engagement. *Journal of Second Language Writing*, 65, 101130. <https://doi.org/10.1016/j.jslw.2024.101130>
- Lai, Y. H. (2010). Which do students prefer to evaluate their essays: Peers or computer program. *British Journal of Educational Technology*, 41, 432-454. <https://doi.org/10.1111/j.1467-8535.2009.00959.x>
- Long, Z., & Qiu, Y. (2024). EFL Writing Learners' Feedback Engagement and Its Influencing Factors in a Multiple-Interaction Environment from An Ecological Perspective. *Modern Foreign Languages*, 47(4), 540-551. <https://doi.org/10.20071/j.cnki.xdwy.20240523.012>
- Niu, R., Shan, P., & You, X. (2021). Complementation of multiple sources of feedback in EFL learners' writing. *Assessing Writing*, 49, 100549. <https://doi.org/10.1016/j.asw.2021.100549>
- Prananto, K., Cahyadi, S., Lubis, F. Y., & Hinduan, Z. R. (2025). Perceived teacher support and student engagement among higher education students – a systematic literature review. *BMC Psychology*, 13(1), 112. <https://doi.org/10.1186/s40359-025-02412-w>
- Qian, J., & Li, D. (2023). Toward a better understanding of student engagement with peer feedback: A longitudinal study. *International Review of Applied Linguistics in Language Teaching*. <https://doi.org/10.1515/iral-2023-0108>
- Rupp, A. A., Casabianca, J. M., Krüger, M., Keller, S., & Köller, O. (2019). Automated essay scoring at scale: A case study in Switzerland and Germany. *ETS Research Report Series*, (1), 1-23. <https://doi.org/10.1002/ets2.12249>
- Shi, Y. (2021). Exploring learner engagement with multiple sources of feedback on L2 writing across genres. *Frontiers in Psychology*, 12, 758867. <https://doi.org/10.3389/fpsyg.2021.758867>
- Thi, N. K., & Nikolov, M. (2022). How teacher and Grammarly feedback complement one another in Myanmar EFL students' writing. *The Asia-Pacific Education Researcher*, 31(6), 767-779. <https://doi.org/10.1007/s40299-2021-00625-2>
- Tian, L., & Zhou, Y. (2020). Learner engagement with automated feedback, peer feedback and teacher feedback in an online EFL writing context. *System*, 91, 102247. <https://doi.org/10.1016/j.system.2020.102247>
- Tsui, A. B. M., & Ng, M. (2000). Do secondary L2 writers benefit from peer comments? *Journal of Second Language Writing*, 9(2), 147-170. [https://doi.org/10.1016/S1060-3743\(00\)00022-9](https://doi.org/10.1016/S1060-3743(00)00022-9)
- van Lier, L. (2004). *The Ecology and Semiotics of Language Learning: A Sociocultural Perspective*. New York: Kluwer Academic Publishers.
- Xu, J., & Long, Z. (2022). Examining student engagement with written feedback in a multiple interaction environment. *Foreign Languages and Their Teaching*, 5, 21-23. <https://doi.org/10.13458/j.cnki.flatt.004895>
- Yan, D., & Zhang, S. (2024). L2 writer engagement with automated written corrective feedback provided by ChatGPT: A mixed-method multiple case study. *Humanities and Social Sciences Communications*, 11, 1086.

<https://doi.org/10.1057/s41599-024-03543-y>

- Yang, Y., & Meng, W. (2013). The effects of online feedback training on students' text revision. *Language Learning & Technology*, 17(2), 220-238. Retrieved from <http://llt.msu.edu/issues/june2013/yangmeng.pdf>
- Yu, S., Zhang, Y., Zheng, Y., Yuan, K., & Zhang, L. (2019). Understanding student engagement with peer feedback on master's theses: A Macau study. *Assessment & Evaluation in Higher Education*, 44(1), 50-65. <https://doi.org/10.1080/02602938.2018.1467879>
- Zhang, Z., & Hyland, K. (2018). Student engagement with teacher and automated feedback on L2 writing. *Assessing Writing*, 36, 90-102. <https://doi.org/10.1016/j.asw.2018.02.004>
- Zhang, Z., & Hyland, K. (2022). Fostering student engagement with feedback: An integrated approach. *Assessing Writing*, 51, 100586. <https://doi.org/10.1016/j.asw.2021.100586>
- Zheng, Y., & Yu, S. (2018). Student engagement with teacher written corrective feedback in EFL writing: A case study of Chinese lower-proficiency students. *Assessing Writing*, 37, 13-24. <https://doi.org/10.1016/j.asw.2018.03.001>
- Zheng, Y., Yu, S., & Liu, Z. (2023). Understanding individual differences in lower-proficiency students' engagement with teacher written corrective feedback. *Teaching in Higher Education*, 28(2), 301-321. <https://doi.org/10.1080/13562517.2020.1806225>

Copyrights

Copyright for this article is retained by the author(s), with first publication rights granted to the journal.

This is an open-access article distributed under the terms and conditions of the Creative Commons Attribution license (<http://creativecommons.org/licenses/by/4.0/>).