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How GenAI shapes STEM EFL students' willingness to communicate: an exploratory interview study using the T-CADS framework

Muyang Niu

Liaoning Institute of Science and Technology, Benxi, China

niumuyanguk@163.com

Abstract. This study explores the mechanisms underlying changes in the Willingness to Communicate (WTC) of STEM undergraduates following a GenAI-assisted English as a Foreign Language (EFL) course. Drawing on semi-structured interviews with 13 first-year STEM students at a university in Northeast China, this study adopted a qualitative analytical framework based on the Topic Modeling-Corpus Assisted Discourse Studies (T-CADS) hybrid approach, integrating NLP-based topic modeling and corpus-assisted discourse analysis to analyze and visualize the interview data. The findings indicate that students' perceptions of GenAI were characterized by three interrelated dimensions: enhanced learning efficiency, low-anxiety interaction, and concerns about technological dependency. Changes in WTC were primarily reflected in greater confidence during classroom communication and increased transfer to authentic out-of-class interactions, although a small number of students demonstrated only context-dependent improvements. The findings further suggest that GenAI does not directly enhance students' WTC but instead facilitates changes through the combined effects of emotional safety, resource availability, and the reconfiguration of communicative contexts. These findings provide empirical support for shifting STEM English classrooms from technology-oriented implementation to communicative task design and suggest that English teachers should place equal emphasis on learner confidence, communicative context design, and the critical use of GenAI.

Keywords: GenAI, willingness to communicate, EFL, topic modeling, corpus-assisted discourse analysis

1. Introduction

As Generative Artificial Intelligence (GenAI) becomes increasingly integrated into college English classrooms, Science, Technology, Engineering and Mathematics (STEM) students have greater access to instant feedback, simulated interactions, and diverse language learning resources. However, whether these technological affordances translate into greater Willingness to Communicate (WTC) in English remains an empirical question. WTC theory suggests that learners' willingness to engage in second language communication at a particular moment is jointly influenced by perceived competence, anxiety, motivation, and the broader classroom ecology, including learning tasks, peer relationships, and social contexts [1, 2]. Existing studies have primarily examined the role of AI chatbots, intelligent tutoring systems, and digital

communication platforms in promoting EFL learners' oral communication and WTC. However, most of this research has relied on quasi-experimental or quantitative designs and has rarely explored how learners themselves connect technological experiences, emotional safety, and authentic communication through qualitative inquiry. STEM students also experience disciplinary learning pressure, varying levels of English proficiency, and a predominantly instrumental orientation toward language learning, suggesting that improvements in WTC may not occur automatically. In learning environments that prioritize problem solving and disciplinary knowledge, English is often regarded as an instrumental tool for accessing information or passing examinations rather than for authentic communication. Without examining learners' own narratives, improvements may be mistakenly attributed to the functions of the technology itself rather than to learners' lived experiences. Therefore, this study investigated 13 STEM students who completed a GenAI-assisted EFL course and addressed two research questions. First, how do students evaluate GenAI-assisted English learning and describe their associated emotional experiences? Second, how does their WTC change following the course, and how are these changes reflected in their discourse on the use of GenAI?

2. Literature review

2.1. WTC in language learning

Research on WTC has shifted the focus of second language learning from learners' linguistic competence to their readiness to initiate communication in specific situations. The heuristic pyramid model proposed by MacIntyre et al. [1] suggests that WTC is jointly shaped by social context, individual emotions, communicative confidence, and immediate communicative intentions. Building on this model, Peng [2], Cao [3], Gu and Sun [4] further emphasized the influence of classroom ecology, teacher support, peer relationships, and nested contextual systems, highlighting that WTC is not a stable personality trait but a dynamic and context-dependent process. Similarly, Barrios and Acosta-Manzano [5] demonstrated that foreign language enjoyment, anxiety, perceived competence, and target language exposure jointly influence adult learners' WTC, providing a useful theoretical basis for examining emotional experiences and perceived competence in qualitative interview studies. Furthermore, the idiodynamic investigation conducted by Li et al. [6] revealed that learners' WTC fluctuates even within the same communicative task as topic familiarity, communicative pressure, and interaction opportunities change, suggesting that overall improvements in WTC should be interpreted alongside learners' situational experiences. More recently, the emergence of digital technologies and artificial intelligence has extended this line of inquiry. For example, Lee and Chiu [7] distinguished between face-to-face and digital communication anxiety, showing that positive online communication experiences do not necessarily transfer to classroom participation. Likewise, Zadorozhnyy and Lee [8] demonstrated that the relationship between informal digital English learning and WTC is mediated by learners' self-efficacy.

2.2. WTC in genai-assisted language learning contexts

The rapid integration of artificial intelligence, particularly GenAI, into foreign language classrooms has attracted increasing scholarly attention. Studies by Fathi et al. [9], Tai and Chen [10], Zhang et al. [11], Wang et al. [12], and Zheng et al. [13] consistently suggest that interaction with AI-powered chatbots, intelligent voice assistants, and large language models can enhance learners' oral performance, reduce communication anxiety, and promote WTC by providing low-threat practice opportunities, immediate feedback, and continuous conversational support. At the same time, these studies also indicate that the effectiveness of AI-assisted language learning is moderated by instructional design, feedback quality, and learners' trust in AI

systems. Similarly, Tran et al. [14], through authentic online conversational tasks, together with Xu et al. [15] in their investigation of emotional experiences in English as a Medium of Instruction (EMI) classrooms and Zhou [16] in discussing learners' socio-emotional needs, jointly argue that improvements in WTC depend not only on the availability of technological tools but also on whether learners are provided with supportive communicative environments.

Despite these advances, several research gaps remain. First, existing studies frequently treat WTC as a post-intervention outcome while paying limited attention to how learners themselves explain changes in their communicative willingness. Second, research on digital language learning has largely compared different technological platforms but has seldom examined the relationship between learners' attitudes toward AI and the transfer of communication beyond technology-mediated contexts. Third, although STEM students are often included as research participants, their disciplinary identity, instrumental orientation toward language learning, and professional learning goals are generally treated as background variables rather than explanatory factors. Within Chinese higher education, STEM students simultaneously face multiple communicative demands, including passing English examinations, reading disciplinary literature, delivering classroom presentations, and preparing for future international academic communication. Consequently, their WTC is likely to vary across different communicative contexts. The value of a small-scale qualitative interview study lies in its ability to capture the complexity of these lived experiences. Rather than seeking to verify a universal causal pathway, it aims to illustrate how learners construct emotional, instrumental, and social meanings around the use of GenAI. Accordingly, this study employed NLP-based topic modeling as an entry point for corpus-assisted qualitative analysis and interpreted learners' experiences using the T-CADS analytical framework. Based on the research gaps identified above, the following research questions were proposed:

RQ1: How do STEM EFL students evaluate GenAI-assisted English learning?

RQ2: How does participation in a GenAI-assisted language learning course influence STEM EFL students' willingness to communicate?

3. Methods

3.1. Data collection

This study adopted an exploratory qualitative research design. Data were collected through semi-structured interviews with 13 first-year STEM students enrolled in an English as a Foreign Language (EFL) programme at a university in Northeast China after they had completed two semesters of GenAI-assisted English courses. Throughout the courses, GenAI tools were integrated into speaking, writing, interactive practice, and real-time feedback activities, with a particular emphasis on language production, revision, and simulated communication supported by AI. Following data collection, all interview transcripts were anonymized, cleaned, and organized to construct the research corpus. To facilitate corpus processing, the interview recordings were transcribed using the DeepSeek-v4-pro API, after which all transcripts were manually checked and corrected to ensure transcription accuracy.

3.2. Data analysis

The data were analyzed using the T-CADS hybrid qualitative analytical framework [17]. The first stage involved Non-negative Matrix Factorization (NMF)-based topic modeling. Separate sub-corpora were created for each interview question, and Term Frequency-Inverse Document Frequency (TF-IDF) vectorization together with topic modeling was implemented using the scikit-learn library in Python. The optimal number of topics k was determined through iterative testing across values ranging from two to five. Model performance

was evaluated using topic coherence, topic diversity, and normalized reconstruction error. Based on the overall performance of these evaluation indices, k = 2 was selected for the Interview Q1 (for RQ1) sub-corpus, whereas k = 3 was selected for the Interview Q2 (for RQ2) sub-corpus.

The second stage consisted of Corpus-Assisted Discourse Studies (CADS). As the NMF output only generated keyword clusters without assigning semantic labels, topic interpretation was conducted by returning to the original interview contexts. This process combined keyword clusters, Keyword in Context (KWIC)-style concordance retrieval, and cross-case comparisons to interpret the underlying meanings of each topic. Guided by Fairclough's three-dimensional framework [18], the analysis was conducted at three interconnected levels. The textual level examined lexical choices and modal expressions; the discourse practice level explored how participants positioned GenAI as a learning tool, interaction partner, or potential source of risk; and the social practice level interpreted how GenAI reshaped resource accessibility, communicative safety, and the distribution of communicative agency in English learning. All subtopics were independently coded by two researchers, achieving a Cohen's Kappa coefficient of 0.89, indicating a high level of inter-coder reliability. The relative weight of each CADS-based subtopic was calculated as the proportion of participants whose interviews contained the corresponding subtopic relative to the total number of valid participants. To enhance the credibility of the analysis, every topic label was grounded in original textual evidence and cross-validated against the NMF keyword clusters, the cross-case comparison matrix, and the research questions.

4. Results

4.1. Topic modeling results

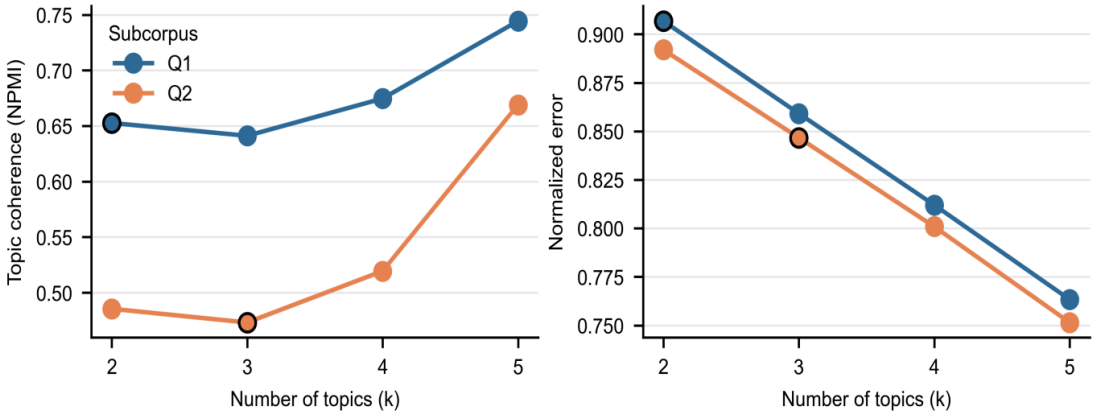

Figure 1. NMF model-selection diagnostics based on topic coherence and normalized reconstruction error

Topic modeling was first conducted to identify semantic entry points in the two interview sub-corpora rather than to generate explanatory themes directly. As shown in Figure 1, the optimal number of topics was determined as k = 2 for the Q1 sub-corpus and k = 3 for the Q2 sub-corpus. For Q1, the model with k = 2 achieved a Normalized Pointwise Mutual Information (NPMI) topic coherence score of 0.653 and a normalized reconstruction error of 0.907. Although increasing the number of topics to k = 3 reduced the reconstruction error to 0.859, the NPMI score decreased to 0.641, and the additional topic showed substantial lexical overlap with the original resource-related topic. Considering both model performance and the

requirement that each topic should be supported by at least three participants, k = 2 was retained because it provided a more concise and interpretable lexical structure.

As illustrated in Table 1, the two keyword clusters generated for Q1 represented two distinct semantic directions. The first cluster contained words such as Baicizhan vocabulary app, vocabulary app, time, words, mobile, and phones, indicating learners' emphasis on mobile-assisted vocabulary learning and resource accessibility. The second cluster included expressions such as double-edged sword and solidify, reflecting conditional evaluations of GenAI together with concerns about potential risks. These results suggest that students' initial perceptions of GenAI-assisted English learning were characterized by both positive evaluations and critical reflections rather than unconditional acceptance.

Table 1. NMF topic results

Corpus	k	Topic ID	Keyword string
Q1	2	Q1_NMF_T1	baicizhan vocabulary app; vocabulary app; baicizhan; time; words; mobile; phones; mobile phones
Q1	2	Q1_NMF_T2	sword; double edged; double edged sword; thinking; convenient; opinion; say; solidify
Q2	3	Q2_NMF_T1	express; confidence; actively; opinions; level; discussions; making; express opinions
Q2	3	Q2_NMF_T2	proactive; environment; language; proactive seeking; classmates teachers; manifested proactive; created; opportunities proactive
Q2	3	Q2_NMF_T3	teacher; interact; interact teacher; increased; vocabulary; willing; want; answer

For Q2, the model with k = 3 achieved an NPMI score of 0.473, which was only slightly lower than the value of 0.485 obtained with k = 2, while the normalized reconstruction error decreased from 0.892 to 0.847. Moreover, each topic remained supported by at least three participants. Compared with the two-topic solution, the three-topic model more effectively distinguished different discourse patterns relating to changes in WTC. The three keyword clusters were: (1) express, confidence, actively, opinions, discussions, and express opinions; (2) proactive, environment, language, classmates, teachers, and opportunities; and (3) teacher, interaction, vocabulary, willing, and answer. The first cluster emphasized confidence in classroom expression and participation in discussions; the second highlighted proactive engagement, communicative opportunities, and supportive learning environments; and the third associated teacher interaction, vocabulary knowledge, and willingness to respond. Overall, the topic modeling results indicate that students' discourse shifted from general evaluations of GenAI to more specific descriptions of communicative behaviour. Rather than simply reporting that they had become "more willing to speak", participants described changes in classroom participation, active engagement in communicative opportunities, and increased willingness to respond with greater vocabulary support.

4.2. CADS results

Building upon the topic modeling results, the CADS returned to the original interview contexts to interpret each keyword cluster as a discourse-based subtopic. As shown in Figure 2, three major themes emerged from Q1. The largest theme, Efficiency Orientation and Resource Expansion, included six participants who primarily described GenAI as a convenient resource for vocabulary learning, information retrieval, language explanation, mobile learning, and access to learning materials. These responses suggest that STEM students

predominantly perceived GenAI as a tool for improving learning efficiency. A second theme, Low-Stress Interaction and Motivation, included two participants who emphasized reduced embarrassment, lower levels of shyness, and diminished evaluation anxiety when practicing English with AI, indicating that GenAI provided a psychologically safe environment for language practice. The third theme, Conditional Acceptance and Dependency Risk, consisted of five participants who acknowledged the convenience of GenAI while simultaneously expressing concerns about excessive reliance on AI, reduced independent thinking, and the reliability of AI-generated responses. Taken together, these findings indicate that students' perceptions of GenAI-assisted English learning were simultaneously shaped by instrumental value, emotional safety, and critical evaluation of potential risks.

The CADS analysis of Q2 revealed three major pathways through which students described changes in their willingness to communicate. The first pathway, identified in five participants, was Increased Classroom Participation Mediated by Confidence. These students reported becoming more willing to answer teachers' questions, express their opinions, and participate in classroom discussions. Their responses suggest that language preparation and immediate feedback provided by GenAI contributed to increased confidence during classroom communication. The second pathway, also represented by five participants, was Transfer to Authentic Communication Beyond the Classroom. These students described extending their communication practices to extracurricular contexts, including online gaming, social interaction, student clubs, classroom presentations, and real-world communication. This finding suggests that improvements in WTC were not confined to classroom activities but also transferred to authentic communicative settings. The third pathway, identified in three participants, was Conditional or Limited Transfer. These students reported that although GenAI was beneficial, their willingness to communicate remained constrained by limited opportunities for authentic communication, insufficient vocabulary knowledge, or continued reliance on AI support.

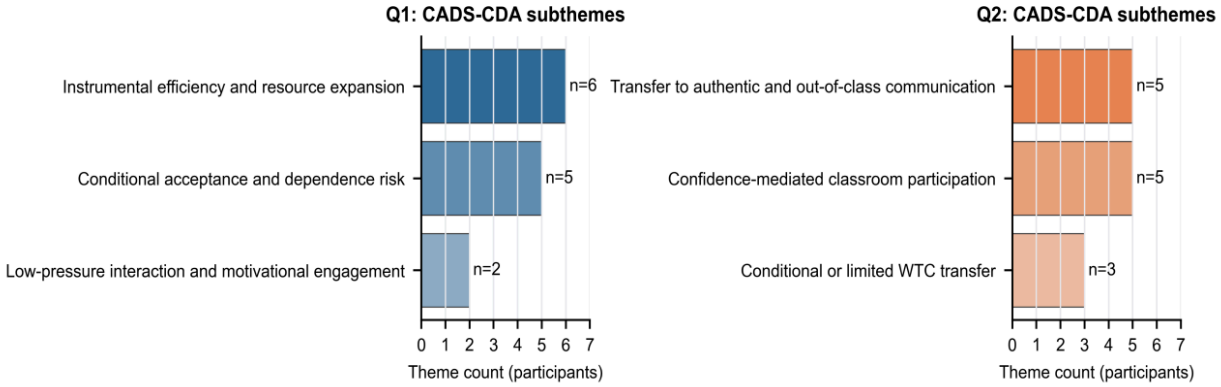

Figure 2. CADS sub-theme results

As presented in Figure 3, the overall distribution of participants further demonstrates that 10 students reported clear improvements in WTC, two students experienced mixed or context-dependent changes, and one participant reported little observable change. These findings indicate an overall positive trend following the GenAI-assisted course while also revealing substantial individual variation. Increased classroom confidence was more commonly associated with relatively protected instructional settings, whereas successful transfer to authentic communication required learners to transform classroom preparation into communicative actions directed toward real audiences. Cases of limited transfer further suggest that technological support may remain at the level of language practice unless learners have sufficient communicative opportunities outside the classroom.

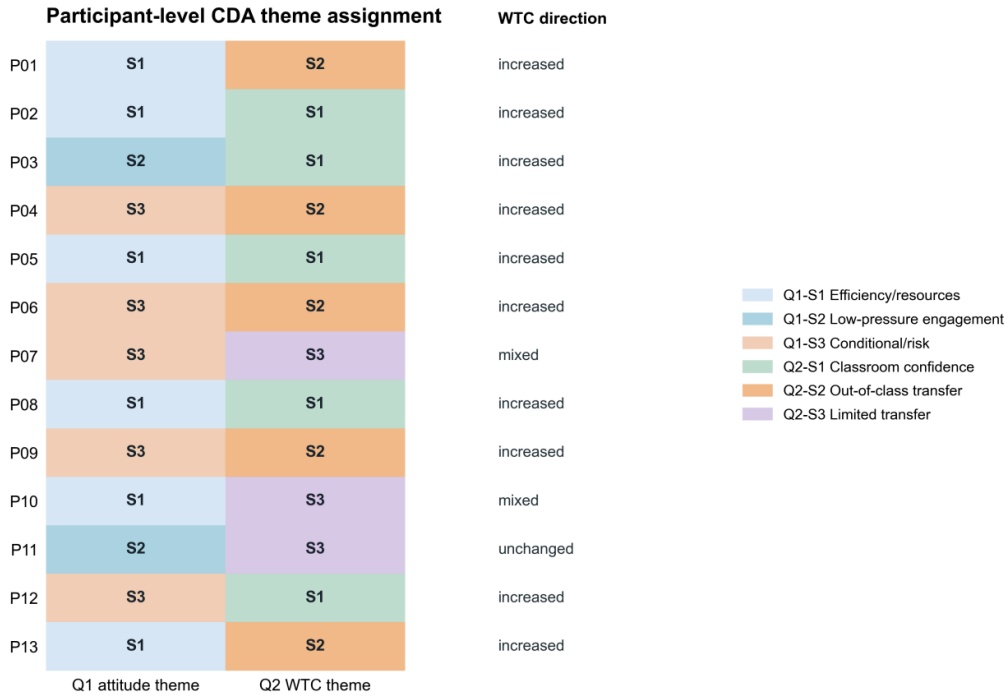

Figure 3. Participant-level CDA theme assignment

The cross-case matrix provides additional evidence that learners followed different developmental pathways. An efficiency-oriented perception of GenAI in Q1 did not necessarily result in the same pattern of WTC development in Q2, and concerns about dependency were not automatically associated with reduced willingness to communicate. Some participants moved from the Efficiency Orientation and Resource Expansion theme to Increased Classroom Participation Mediated by Confidence, suggesting that AI-supported vocabulary learning and immediate feedback reduced the cognitive burden associated with preparing for oral communication. Others progressed from Efficiency Orientation and Resource Expansion to Transfer to Authentic Communication Beyond the Classroom, indicating that technological support functioned as scaffolding before learners engaged in real-world communication. Interestingly, several participants classified within the Conditional Acceptance and Dependency Risk theme also reported noticeable improvements in WTC, implying that maintaining a critical attitude toward GenAI did not necessarily hinder communication but instead enabled learners to distinguish more clearly between AI-assisted preparation and their own communicative performance. In contrast, participants who demonstrated only limited transfer generally lacked sufficient opportunities for authentic communication, supportive peer interaction, or adequate vocabulary knowledge. Although they acknowledged the usefulness of GenAI, improvements were primarily reflected in increased psychological readiness rather than observable communicative participation. Overall, the findings suggest that GenAI does not produce a uniform technological effect but instead supports different learners in different ways as they selectively transform technological resources into communicative action across diverse learning contexts.

5. Discussion

The findings of this study provide a more nuanced understanding of the widely discussed claim that GenAI enhances learners' WTC. First, students' positive evaluations of GenAI primarily originated from its ability to

expand learning resources and improve learning efficiency. This finding is consistent with previous studies showing that AI-assisted interaction lowers the barriers to language practice and creates additional opportunities for oral communication [9-11]. However, the present study further suggests that improvements in learning efficiency alone are insufficient to promote changes in WTC. Rather, WTC is more likely to develop when learners perceive GenAI as facilitating emotionally safe practice, supporting language preparation, and creating opportunities for authentic communication. In other words, the transition from learning English with AI to communicating with other people requires more than technological convenience.

Second, the pathway of increased classroom confidence identified in this study supports previous findings emphasizing the importance of foreign language enjoyment, anxiety, and perceived competence in shaping learners' WTC [5, 15]. It is also consistent with Zheng et al. [13], who reported that large language models can reduce foreign language anxiety. Nevertheless, the cases of limited transfer observed in the present study indicate that reduced anxiety within AI-assisted learning environments does not necessarily extend to face-to-face communication. Instead, decreases in anxiety may remain confined to AI-supported interaction or protected classroom settings. This finding echoes Lee and Chiu's [7] distinction between digital communication anxiety and face-to-face communication anxiety, suggesting that confidence developed in technology-mediated environments may not automatically transfer to authentic communicative contexts. Third, the pathway of transfer to communication beyond the classroom further supports the findings of Tran et al. [14], who highlighted the importance of authentic online interaction for developing communicative willingness. The present findings similarly suggest that sustainable communicative contexts, shared tasks, and interaction with real audiences provide stronger support for WTC than technological tools alone. While GenAI may facilitate preparation for communication, the development of WTC ultimately depends on learners' opportunities to participate in meaningful communicative situations.

Finally, the findings also reveal a distinctive characteristic of STEM learners. Owing to their disciplinary background, GenAI is easily incorporated into an efficiency-oriented and problem-solving approach to English learning. This tendency represents both an advantage and a potential limitation. On the one hand, GenAI enables learners to quickly overcome vocabulary gaps, organize ideas, and rehearse language before communication. On the other hand, excessive reliance on these functions may lead learners to conceptualize English learning primarily as tool use rather than as participation in authentic social communication. Consequently, the educational value of GenAI should not be understood merely in terms of technological efficiency but also in terms of its capacity to support meaningful communicative engagement.

6. Conclusion

This study investigated changes in STEM EFL students' WTC following a GenAI-assisted English course using the T-CADS hybrid qualitative analytical framework. Drawing on semi-structured interviews with 13 STEM undergraduates, the findings indicate that students generally perceived GenAI as both an efficient learning resource and a low-pressure environment for language practice while simultaneously recognizing the potential risks of technological dependency and reduced independent thinking. Improvements in WTC were primarily reflected in greater confidence during classroom communication and increased transfer to authentic communication beyond the classroom, although several students continued to demonstrate only context-dependent changes.

The primary contribution of this study lies in combining topic modeling with corpus-assisted discourse analysis to examine learners' experiences in depth. Rather than treating algorithm-generated topics as direct interpretations, topic modeling was used only to identify lexical entry points, while CADS was employed to

explain how meanings were constructed within learners' discourse. This analytical process provides a more transparent approach to interpreting qualitative interview data and demonstrates how computational techniques can complement qualitative discourse analysis in small-sample studies. From a pedagogical perspective, the findings suggest that the value of GenAI in STEM English education lies not simply in increasing the frequency of technology use but in integrating AI-supported feedback, peer interaction, and authentic communicative audiences into both classroom instruction and out-of-class learning. The design of GenAI-assisted activities should therefore address learners' communicative needs as well as their emotional support needs while being complemented by teacher guidance, peer collaboration, and authentic communicative tasks. At the same time, teachers should help learners recognize the limitations of AI-generated responses and encourage them to transform AI feedback into their own communicative resources rather than relying on AI as a source of ready-made answers. This, in turn, places increasing demands on teachers' own AI literacy and pedagogical competence. Several limitations should also be acknowledged. The relatively small sample size and the focus on STEM students at a single university limit the generalizability of the findings. Future research could incorporate additional qualitative data sources, such as classroom observations, learning journals, and longitudinal follow-up interviews, while expanding the participant pool to examine the long-term development of WTC among a broader population of EFL learners in GenAI-supported learning environments.

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