

Interaction and CALL: Insights from Thirty Years of Research

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Abstract

Since Chapelle's series of influential articles (1997, 1998, 2001, 2005, 2009), the field of computer-assisted language learning (CALL) has grown markedly, with technology having become an integrated part of learners' lives and educational experiences (Godwin-Jones, 2022; González-Lloret, 2020). Responding to Chapelle's call to action to integrate research methods and theories from second language acquisition (SLA) into investigations of technology-mediated language learning, the field has grown and matured, providing a range of insights into how technology might support second language (L2) development. In addition, technologies for language learning and teaching have become increasingly "normalized" (Bax, 2003), with teachers having access to a variety of tools for the L2 classroom, such as internet-based resources or video-conferencing platforms like Zoom (Kessler, 2018). Taking a reflective perspective, this paper reviews key insights from the past thirty years of technology-mediated interaction research, exploring how technologies have improved our understanding of interactional processes as well as how interaction supports the language learning experience in technology-mediated contexts.

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1 Introduction

The field of computer-assisted language learning (CALL) has grown exponentially during the past few decades, shifting from what Bax (2003) referred to as a *Restricted CALL* system, in which learners had minimal interaction with other learners and primarily used closed drills or text reconstruction as instructional activities, to *Integrated CALL*. At the time, Bax (2003) described *Integrated CALL* as the use of computer-mediated communication (CMC) to foster integrated skills practice through frequent learner-

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learner interactions. Importantly, Bax (2003) noted that this level of CALL did not yet “exist to any significant degree” (p. 22). Instead, Bax highlighted the potential for technology to become “embedded in everyday practice and hence ‘normalized’” (p. 23). Since the publication of Bax’s article, the field has grown and evolved to meet this vision for *Integrated CALL*, with educators having access to a wide variety of technological tools that can be utilized to serve “the needs of learners” and be “integrated into every teachers’ everyday practice” (Bax, 2003, p. 27). For example, Kessler (2018) highlights the extensive choices available to educators in terms of technologies, describing the ‘unprecedented opportunities’ that language teachers have to use technology mediated tools to support language learning. In addition, many of these technologies are an integral part of both teachers and learners’ daily lives (González-Lloret, 2020; Kessler, 2018), demonstrating the potential to leverage this familiarity to promote engaging language learning experiences.

As CALL has become more ‘normalized’ over the years, meaningful interaction has concurrently been established as a key component of much contemporary CALL research and materials design (Hegelheimer et al., 2018). This is a result of a substantial shift in the field from early CALL design, in which interaction was not considered necessary for learning (González -Lloret, 2023), to what Bax (2003) referred to as *Open CALL*, which provided more interactive and meaningful L2 learning opportunities. For example, Chun’s (1994) findings showed the potential benefits of computer-mediated communication (CMC) for class discussion as well as oral production, with findings indicating learners provided feedback and increased their participation. Similarly, in one of the earlier studies examining synchronous text-chat, Smith (2003) investigated negotiation patterns during task-based interaction, with results demonstrating that learners engaged in negotiation following miscommunication or misunderstandings. Findings from these early studies inspired increasing interest in examining the features of interaction in CMC contexts, with CMC eventually becoming one of the most well-researched types of technologies within the field (Chun, 2016; Chun et al., 2016; Kim & Namkung, 2024).

Looking back at these important shifts from structure-based CALL to the more interactive practices and investigations that dominant the research landscape today (González-Lloret, 2023), this increasing attention to the role of interaction was undoubtedly inspired by a series of highly influential articles in which Chapelle (1990, 1997, 1998, 2001, 2005) suggested theories of SLA should play a more substantial role in CALL research design. Specifically, Chapelle encouraged CALL researchers to consider interaction as an established framework in which to facilitate investigations of interactional processes that promote L2 learning, development, and production. Drawing attention to some of the same criticisms targeting initial interaction research, such as vague research methods or unclear reporting, Chapelle (1990) noted that initial studies

focused on the type of technology, highlighting the need for more empirical explorations of L2 processes and experiences.

Building on this early research, Chapelle's work continued to highlight the importance of drawing on SLA theories and perspectives to inform CALL (Chapelle, 1994, 1997, 1998, 2001), underscoring the importance of learner language and oral interaction. Drawing attention to the potential for technology to create environments conducive to L2 learning and production, as well as how technology could be applied to the L2 classroom, rather than on descriptions of the technology itself, Chapelle (1998) described the interactional constructs that might be used to inform CALL research and practice, such as promoting modified input and output, increasing the salience of target features, and providing opportunities for negotiation and noticing. These design-based guidelines were grounded in research exploring interactional conditions found to be facilitative of L2 development and learning (Long, 1983; Pica, 1996), such as the Interaction Hypothesis (Long, 1996) and Swain's Output Hypothesis (1985, 1995), thus providing scholars and instructors with a theoretically motivated framework for examining L2 interaction in computer-assisted environments (González-Lloret, 2017).

Drawing on Chapelle's work, computer-assisted research expanded to investigate to what extent the features and benefits of face-to-face (FTF) interaction could be found in CMC interactions, with findings showing negotiation for meaning and corrective feedback, as well as increased salience, in text-chat interactions (e.g., Payne & Whitney, 2002; Smith, 2003, 2004). These findings highlighted the unique affordances that CMC offered, such as additional opportunities for learners to attend to L2 forms through the real-time written record of text-chat interactions (e.g., Pellettieri, 2000; Smith, 2003). In addition, Web 2.0 and CMC technologies provide opportunities for learners to engage in authentic, contextualized second language (L2) experiences with interlocutors beyond the physical boundaries of the classroom, providing opportunities for learning, community building, and social engagement (González-Lloret, 2020; Kessler, 2018). In other words, this research not only provided empirical evidence that interaction in computer-mediated environments, specifically CMC, fostered similar developmental opportunities as interaction in FTF contexts, but also offered unique affordances specific to different technologies.

According to Chapelle (1997), scholars and researchers needed to better understand the quality of the learning experience, as well as the language produced, during CALL activities. Subsequent research also sought to explore how technology might deepen our understanding of SLA processes as well as how interaction could support L2 learning in technology-mediated contexts. Taking Chapelle's influential work in the late 1990s and early 2000s as a starting point, this paper seeks to highlight the growth of technology-mediated interaction research over the last three decades by reviewing key topics in interaction and CALL. How has technology helped us to better understand the cognitive

processes of SLA? Reciprocally, how has an interactional framework helped us to better understand the affordances of technology? Taking a reflective perspective, this paper seeks to address these questions by reviewing key findings and insights from research exploring interaction and CALL over the past three decades.

Foundations and Background

The interaction approach to SLA (Mackey, 2020) posits that the interactional modifications that occur during conversation and in response to communicative failures foster an environment facilitative of L2 learning. For example, interaction provides comprehensible input and opportunities for learners to engage in negotiation for meaning, such as in response to a communication breakdown, to produce modified output, and to notice differences between their errors in production and the more target-like production of an interlocutor. Long's early research (1981, 1983) exploring learner-native speaker interactions demonstrated that interlocutors make interactional modifications in response to communication issues, thus making their input more comprehensible. This observation formed the foundation for negotiation for meaning, with later research illustrating the importance of output to learning (Swain, 1985, 1995, 2005). For instance, Swain's work demonstrated the deeper syntactic processing that learners experience when producing output, as well as the opportunities for hypothesis testing and modified output following feedback. In addition, research has highlighted noticing as a necessary condition for L2 learning (Schmidt, 2001), especially in terms of directing learners' attention to recognizing any differences between the input and their production. Together, these constructs were incorporated into later iterations of the Interaction Hypothesis, with Long suggesting that "negotiation for meaning, and especially negotiation that triggers interactional adjustments by the native speaker or more competent interlocutor, facilitates acquisition because it connects input, internal learner capacities, particularly selective attention, and output in productive ways" (1996, p. 451). Hundreds of empirical studies and syntheses have since demonstrated the efficacy of interaction for L2 development across diverse laboratory and classroom settings as well as for a wide range of learner populations (e.g., Mackey & Goo, 2007; Ziegler, 2016a).

Following Chapelle's call to integrate theoretical foundations from SLA into CALL research, researchers turned their attention to better understanding the benefits and challenges associated with interaction in CMC contexts. Drawing on the methodological frameworks, research designs, and operationalizations of learning associated with the interaction approach to SLA (Mackey, 2020), early descriptive research sought to better understand to what extent interactional processes occurred in CMC environments. For example, Pellettieri (2000) found similar patterns of negotiation across FTF and text-chat, with findings also highlighting one of the key affordances of this modality: additional time for learners to process and self-monitor their L2 production. Due to the slower nature of text-chat interactions (e.g., Beauvois, 1992), in which there may be a longer

duration between turn-taking and extended response times due to variations in typing speed, learners may have increased processing times compared to FTF interactions. This slowing down of the interaction may then reduce cognitive pressures, including strain on learners' working memory, freeing up attentional resources and providing learners with opportunities to attend to form or monitor self-production (e.g., Smith, 2004; Payne & Ross, 2005; Payne & Whitney, 2002; Warschauer, 1997). Research also demonstrated how interactional patterns in CMC may differ from FTF (Smith, 2003), with results underscoring the need for a model of negotiation that accounted for the non-adjacency of turn-taking and responses unique to technology-mediated text-chat environments. Grounded in interactional frameworks, Smith's (2003) model provided a foundation for future research exploring negotiation in CMC contexts.

Similar to trends in early FTF interaction research (e.g., Gass & Varonis, 1985), initial research focused on descriptive, observational studies rather than on causal effects of types of technology on L2 development. However, rising to Chapelle's (1997, 1998) call to integrate evaluative methods to explore L2 learning outcomes, researchers soon shifted their focus from studies examining whether features of FTF interaction occurred in CMC to exploring the extent that interaction in CMC promoted L2 learning and production, with numerous studies comparing the quality and quantity of interaction across computer-mediated contexts and more traditional, FTF environments.

Technological Affordances for Interaction

Interactional and Developmental Benefits

Continuing to expand this early research, an increasing number of studies have explored how interaction in various technology-mediated environments can promote L2 development and production, with numerous studies and syntheses seeking to highlight the unique technological affordances related to SLA (e.g., Bryfonski et al., 2025; Ziegler et al., 2022). For instance, findings suggest CMC increases accessibility to target-language input and offers more time for processing compared to interaction in FTF contexts, which in turn may support learners' noticing and self-repair. For example, the visual transcript generated during text-chat offers learners opportunities to direct their attention to production and "gain control over more cognitively demanding aspects of grammar that otherwise might not be so frequently practiced in classroom oral interaction" (Pellettieri, 2000, p. 82). Later work provided further evidence for Pellettieri's (2000) observation, with results demonstrating that learners produced similar patterns of negotiation to FTF interaction (e.g., Tudini, 2003) and improved their metalinguistic awareness through self-monitoring during text-chat interactions (Blake, 2000), suggesting that text-chat may facilitate improvements across both form and meaning. In addition, Toyoda and Harrison (2002) found that reviewing text-chat logs following an interaction allowed learners to direct their attention to their production, providing opportunities for noticing and subsequent development. Similarly, Lai and Zhao's (2006) findings provide evidence for how learners took advantage of these affordances to support their L2 learning

experience, including using the visual record of their text-chat conversation and the longer processing times to review previous utterances and self-correct their own production. Smith (2009) later found that scrolling through the text-chat transcript supported self-repair, as this provided learners with opportunities to review their own production while Sotillo (2010) found text-chat produced nearly twice as many instances of noticing than voice-chat. Similarly, research has highlighted the affordances of technology for noticing, with Smith (2012) finding learners noticed recasts more than half of the time they were provided in text-chat.

Research has also demonstrated that learners may attend to form and produce more LREs during text-chat than in FTF conditions (e.g., Shekary & Tahririan, 2006), with text-chat facilitating learners' noticing (e.g., Chen, 2008). The longer processing time available to learners during text-chat may reduce the cognitive burden during interaction, freeing up working memory for other attentional demands, including attending to form, noticing, and self-repair. Indeed, research has suggested that CMC may encourage self-monitoring (e.g., Sauro & Smith, 2010), with recent findings highlighting how beginning level learners may draw on the visual record and additional time to more carefully monitor their own production (Moranski et al., 2024) and notice corrective feedback (e.g., Lai et al., 2008; Yilmaz, 2012). However, despite the advantages presented by a slower paced interaction, findings have highlighted how the non-contingency of recasts and their triggers may have a negative impact on negotiation and noticing (e.g., Lai et al., 2008; Smith, 2009; Ziegler, 2018a), as learners may fail to connect the feedback to the error.

Importantly, Smith and Gorsuch (2004) highlighted the possible insufficiency of text-chat transcripts alone for capturing learners' cognitive processes during CMC interactions, with Smith (2008) calling for interactions to be recorded using multiple methods. Sauro and Smith (2010) illustrated the use of video-enhanced chat-scripts, in which screen capture technology was used to record what learners produced and then deleted (thus failing to transmit certain messages to their interlocutors) as well as the addition and deletion of text following the initial production and prior to transmission. Using screen-capture software to create video-enhanced chat-scripts not only provides researchers with a unique opportunity to observe learners' composition process during text-chat interactions, but also to obtain evidence of difficult to measure constructs like noticing (Smith, 2010). These methodological advantages allow observation of "what learners are capable of doing, rather than only what they choose to contribute to an interaction" (Ziegler, 2018b, p. 208), providing researchers with an otherwise inaccessible view of learners' interactional processes.

Although a number of these key benefits, such as extended processing time and reduced cognitive burden, have been associated with text-chat, research has highlighted how different modalities can promote L2 development and performance in other ways. For example, previous research has found that voice-chat may promote increased production

of negotiated repair moves during interaction compared to FTF contexts (e.g., Blake 2009; Jepson, 2005). More recently, Bueno-Alastuey's (2010, 2011) comparisons of voice-chat and FTF interactions found greater gains in voice-chat, regardless of whether learners had a homogenous L1 background with their interlocutor. Similarly, Yanguas (2010) found advantages for voice-chat compared to video-chat and FTF interaction, with findings showing higher amounts of negotiation and elaboration for voice-chat interaction. Later research provided further evidence of these affordances, with results illustrating differences in interactional features, such as negotiation, across text-, video-, and voice-chat (e.g., Yanguas, 2012). Taken together, these findings suggest that the audio-only nature of voice chat may help learners direct their attention to forms, as the lack of visual input may reduce distractions and attentional demands. However, some studies found no differences across voice-chat and FTF in terms of focus on forms (Loewen & Wolff, 2016), suggesting that although there may not always be advantages associated with technology, learners nonetheless have similar developmental opportunities as in FTF contexts (Ziegler, 2016a). In addition, Payne's (2020) recent work exploring the cognitive load in different modalities suggests that SCMC interactions are more cognitively demanding than asynchronous technologies, underscoring González-Lloret and Ortega's (2014) point that technologies are not neutral. Rather, learners' perceptions, familiarity, and degree of technological literacy may impact the cognitive demands and difficulty of technology-mediated interaction, underscoring the importance of considering the affordances in conjunction with the challenges of different technologies and their intended purpose.

Research has also highlighted the potential for technology to extend opportunities for authentic interaction beyond the constraints of the traditional classroom. For example, traditional classrooms have often faced challenges in terms of providing authentic interactional opportunities for learners, particularly in foreign language contexts where access to the target-language is often limited. Due to their ability to transcend physical boundaries, Web 2.0 technologies in particular have been shown to promote connections between learners, as well as native speakers, outside of the classroom (e.g., Bueno-Alastuey, 2011; Golonka et al., 2014; González-Lloret, 2020; Lai., 2013). More recently, studies have illustrated how video-chat can provide not only developmental benefits (e.g., Canto & Ondarra, 2017) but also promote cultural understanding and engagement (Loewen et al., 2022). Generative Artificial Intelligence (AI) tools, such as Chat GPT, may also provide interactional opportunities, as chatbots can be directed to take on the role of an interlocutor or language tutor, thus extending opportunities in contexts where interacting with target language speakers is limited (Godwin-Jones, 2024).

Studies have also illustrated how affordances may extend to other interactional features beyond negotiation for meaning and learners' focus on forms, including Language Related Episodes (LREs, Swain & Lapkin, 1998). For example, research has investigated how modality may impact the quantity and resolution of LREs, operationalized as "any part of

a dialogue where the students talk about the language they are producing, question their language use, or correct themselves or others” (Swain & Lapkin, 1998, p. 326), across varying technology-mediated environments. For example, results suggest that LREs occur less frequently in text-chat than in video-chat or FTF interaction (Loewen & Wolffe, 2016). However, results are mixed, with findings demonstrating learners produced and resolved a greater number of LREs in FTF than voice-chat (e.g., Loewen & Isbell, 2017; Yanguas & Bergin, 2018). Torres and Cung’s (2019) investigation of heritage language learners suggested that although more LREs were produced during FTF interactions, learners had higher rates of self-repair in text-chat interactions. Learners also produced significantly more LREs in video- and voice-chat compared to text-chat interactions (Torres & Yanguas, 2021), indicating that there may be important differences across modalities.

Similarly, Ziegler and Phung (2019) also found differences across text-, voice-, video-, and multimodal-chat, with results indicating that more LREs were produced and resolved in the multimodal-chat than in the other conditions. Findings illustrate how interlocutors used a range of tools in the multimodal-chat, including white-boards, video-chat, and text-chat, to negotiate and resolve LREs during interaction. The benefits afforded by multiple interactional tools were further demonstrated by Bryfonski and Ma (2020), in which feedback was provided to learners using video- and text-chat. Findings illustrate how the affordances of multimodal chat allowed the researchers to target input according to learners’ preferences or needs, thus enhancing the benefits of recasts. Despite these promising findings, learners may not perceive the benefits of multimodal interaction. For instance, although multimodal interaction facilitated more LREs and subsequent developmental opportunities, learners preferred video-chat in Ziegler and Phung’s (2019) study. Learners also indicated text-chat was their least preferred modality as they perceived it as difficult to use for task completion. These findings highlight the need to continue to explore how different modalities may impact learners’ perceptions and performance.

Overall, research has revealed that learners can benefit from interactional processes facilitative of SLA, such as negotiation and noticing, in technology-mediated environments. In addition, findings have illustrated the unique affordances of various technologies that may provide additional support to the language learning experience, including longer processing times and increased opportunities for interaction beyond the L2 classroom. Although Zheng and Warschauer (2017) point out that “various mediating factors contribute to the degree and quality of interaction and collaboration, including task type, mode selection, participants’ characteristics, learning styles and preferences” (p. 63), a substantial and growing body of work has demonstrated how established and emerging technologies can play a facilitative role in promoting the developmental and performance related benefits associated with interaction.

Affective and Emotional Benefits

As investigations into the developmental and cognitive benefits associated with interaction and CALL have grown, studies have also explored how affective and emotional factors may be mediated or impacted by technology. For example, early CALL research highlighted the potential for interaction in technology-mediated environments to foster a less anxiety-provoking language learning experience (e.g., Chun, 1998), an important advantage since speaking is hypothesized to be a primary source of anxiety for language learning (e.g., Tai & Chen, 2022). These studies suggested that text-chat in particular might offer learners similar developmental benefits as FTF interaction but without the same social pressures that may cause learners to withdraw from participation or prevent them from fully engaging in conversation with their peers. For example, early research suggested that CMC may encourage students' production, potentially facilitating equity in terms of interactional opportunities (e.g., Chun, 1994; Kelm, 1992; Kern, 1995; Warschauer, 1996). When using text-chat, some learners may be more likely to participate in online conversations (Kern, 1995) or may experience less anxiety (Warschauer, 1997). These early findings are supported by more recent research demonstrating task engagement, enjoyment, and more equitable participation and production during technology-mediated interaction (Cheung, 2021; Zhang et al., 2021). Together, these studies highlight the potential affective affordances of technology-mediated contexts.

Research has also suggested that technology-mediated contexts may be beneficial in terms of reducing learners' anxiety. For example, learners may experience less anxiety due to the anonymous nature of some technologies, such as text-chat or avatars, thus removing or reducing social distance (Marjanovic, 1999). Processing and cognitive pressures may also be alleviated due to the slower interactional pace of text-chat (Beauvois, 1992). Text-chat thus not only provides additional time for learners to consider the input and formulate their response, but also offers an interactional experience in "an anonymous, less pressured environment that tends to lower the affective filter" (Beauvois, 1997, p.171). These affordances demonstrate the potential for text-chat in particular to lessen anxiety and promote participation and production (Abrams, 2003; Tudini, 2007). An & Li's (2024) recent exploration of text-chat provides additional support for Beauvois' suggestion, with findings demonstrating attributing learners' lessened anxiety to the additional time for processing and planning afforded during text-chat interactions.

Given that anxiety may be one of the primary factors negatively impacting L2 learning (e.g., Gardner & MacIntyre, 1993; Horwitz, 2001), researchers and teachers have explored how anxiety may be reduced or managed to more effectively foster language learning. Since these initial studies exploring how technology might offer learners affordances to mitigate anxiety in the L2 classroom, research findings have been somewhat mixed. For example, Baralt and Gurzynski-Weiss (2011) found no effects for

modality on learners' anxiety, while the results of Côté and Gaffney (2018) indicated learners experienced less anxiety and produced more turns for learners interacting in CMC than learners in FTF interaction. More recently, Liu (2023) compared FTF, SCMC, and a bring-your-own-device (BYOD) condition for SCMC. The BYOD condition included smartphones, internet, or personal laptops, with results indicating that learners produced higher quality interaction than in the traditional SCMC or FTF conditions. In addition, both SCMC and BYOD reduced learners' foreign language anxiety, although learners reported feeling more distracted when using traditional SCMC. Using an audio-only mobile assisted language learning app, Ebadi and Azizmajid (2024) explored how voice-chat might impact the foreign language anxiety and oral proficiency of upper intermediate learners. Results demonstrate that interaction using the voice-chat app promoted gains in oral proficiency as well as reduced learner anxiety compared to traditional FTF classes.

Turning to other modalities, Satar and Özdener (2008) investigated learners' anxiety in text- and voice-chat, with findings demonstrating that both modalities promoted gains in oral proficiency but voice-chat failed to decrease anxiety to the same extent as text-chat. Text-chat may have been less face-threatening for learners than voice-chat, potentially contributing to the greater reduction of anxiety for text-chat. Similarly, van der Zwaard and Bannink (2014) suggest that interacting in text-chat may have encouraged learners to more willingly engage in negotiation than in video-chat. More recently, Muntaha et al. (2023) explored text-, voice-, and video-chat using Instagram as a communication platform. Learners completed seven interactional tasks, with results demonstrating that students overall had positive perceptions of all three modalities. However, learners reported drawing on paralinguistic features, such as emojis, GIFs, and gestures, to support their communication, suggesting that the multimodal chat feature may provide a wider variety of affordances for communication during interaction. Together, these findings suggest that technologies that support affective and emotional factors, such as saving face, anxiety, or willingness to communicate, may promote learners' active participation and engagement in the interaction, thereby also providing more developmental opportunities than in modalities that fail to offer the same type of socio-affective support.

As technologies have continued to evolve, studies have expanded beyond text-, voice-, and video-chat to explore how emerging technologies might create a more welcoming language learning experience. For example, research exploring virtual worlds has suggested that learners may experience less anxiety and boredom, as well as higher levels of willingness to communicate (e.g., Kruk, 2022; Melchor-Couto, 2017; Reinders & Wattana, 2014). For example, Jauregi et al. (2011) compared interaction in a virtual world with video synchronous computer-mediated communication (SCMC), with learners reporting feeling more comfortable using avatars in virtual worlds than when using SCMC. Similarly, Melchor-Couto's (2018) findings suggest that the opportunities for

anonymity provided by avatars and virtual reality may reduce learners' anxiety during interaction (e.g., Melchor-Couto, 2018).

Research has also illustrated developmental and affective benefits for virtual reality (VR), with studies showing improved oral skills, a greater sense of purpose, and increased motivation during interaction (Canals, 2020). VR may also help reduce anxiety for some learners. For example, York et al. (2021) found that learners had decreased foreign language anxiety in text-chat, video-chat, and a virtual environment. However, learners reported that they felt virtual reality (VR) was the most enjoyable and most effective in terms of their learning experience. York et al. also suggested that learners' overall preferences for technology may be a driving factor in terms of their various perceptions of the affordances of VR.

More recently, the field has dedicated attention to exploring the effects of AI, with generative and interactive AI tools, such as ChatGPT or other chatbots, becoming increasingly common as a resource for many learners (Bibauw et al., 2022). Not only can AI tools provide another platform for interaction, thus offering further opportunities to support L2 development and performance, AI potentially extends accessibility due to its availability via smartphones or personal electronic devices (Godwin-Jones et al., 2024). For example, AI tools are always available and can be individualized according to learners' preferences, proficiency levels, or in terms of target features (Godwin-Jones, 2024; Rezai et al., 2024). In addition, interaction with ChatGPT may reduce learners' anxiety (Hayashi & Sato, 2024). However, because AI is evolving rapidly, there is a clear need for continued research on how AI tools might best be used for learning and teaching (Godwin-Jones, 2024).

Research findings have demonstrated that various technologies and technology-mediated tools may reduce anxiety, support engagement, and promote more equitable and considerate participation (e.g., Kohnke & Moorhouse, 2022; Maican & Cocoradă, 2021). Studies have also identified a number of challenges related to technology-mediated interaction, however, including maintaining learner interest (Ma, 2020) and issues related to distraction (Murray et al., 2020). As technologies continue to emerge and involve, further exploration into how the affordances of technology might reduce anxiety and encourage participation is needed (Kessler, 2018).

Methodological Improvements

Alongside the integration of SLA theory and practices, CALL research methods and designs have similarly matured during the last three decades, responding to concerns by scholars regarding the methodological rigor of interaction studies in CALL contexts (e.g., Chapelle, 2001; Liu et al., 2002). For example, early empirical CALL studies were criticized for poor rigor in terms of research design (Chapelle, 1997; Felix, 2008), highlighting areas for improvement. More recently, Cerezo et al.'s (2014) methodological

review demonstrated multiple studies did not meet the criteria of Leow (1999) for reliability and validity, suggesting the need for continued improvement in future work. Similarly, Leow & Suh (2015) identified a number of methodological challenges in studies comparing SCMC and FTF, such as the lack of a true control group, uncontrolled external exposure to input or instruction, and lack of reporting of time on task. Similar to findings in FTF research (e.g., Plonsky & Gass, 2011), their review illustrated the need for improved reporting of treatment conditions, highlighting the need for continued attention to methodological quality in future research.

Subsequent reviews have demonstrated improvements in terms of study design and reporting, with many of these sound research practices, such as quasi-experimental designs or control groups, now more commonplace. For example, Ziegler's (2016b) synthesis of research exploring interaction in CALL contexts describes improvements in terms of study quality and reporting since the early 2000s, with trends demonstrating increasing use of pre- and post-test designs and descriptive statistics. More recently, Kim and Namkung's (2024) methodological review of technology-mediated task-based interaction found positive improvements in terms of statistical use and reporting compared to earlier reviews (e.g., Plonsky & Kim, 2016), although Bryfonski et al. (2025) note the potential risk of Type-I errors in technology-mediated TBLT research due to possible overreliance on certain statistical tests. Importantly, Kim and Namkung's (2024) review also demonstrated the essentialness of technology to many study designs, rather than the use of technology due to novelty. In other words, much of the research exploring task-based interaction in technology-mediated contexts has integrated technology seamlessly, suggesting Bax's 'normalization' of technology is well underway in terms of study design.

Conclusion

Chapelle (2013) suggests that researchers examining technology-mediated language learning "hope to make a range of assertions about the quality of interactions, acquisition of particular linguistic features, benefits of intercultural encounters, and users' opinions about specific aspects of the activities" (p. 4). During the past three decades, studies have produced a robust body of evidence regarding these claims through research examining learners' language during technology-mediated activities or tasks, the efficacy of the technology for L2 learning processes and outcomes, and learners' perceptions of these experiences. Findings have not only demonstrated that the developmental benefits associated with interaction in FTF contexts are available in technology-mediated environments, but that there are also unique affordances of various technologies, including text-, voice-, and video-chat and virtual worlds, that support socio-cognitive processes facilitative of SLA. For example, CMC research has highlighted how learners may benefit from additional processing time for noticing and self-repair, as well as how the environment of technology-mediated interaction may mediate anxiety or encourage engagement. In addition, technology-mediated environments provide new research

contexts and resources, such as the use of screen-capture technology or generative AI, to improve our knowledge of learners' behaviors during interaction.

Overall, the affordances of technology identified during the past three decades have enhanced our understanding of not only the interactional processes associated with SLA, but how different technological tools might be used to facilitate and foster L2 learning. Many technologies are now closer to what Bax (2003, 2011) termed 'normalized,' with learners and teachers regularly using a rich variety of technology-mediated tools both for educational and personal purposes (Kessler, 2018). However, as González-Lloret (2020) has pointed out, technologies are continually evolving and changing over time, highlighting the importance of focusing future explorations on the affordances of the tools rather than the tools themselves as the tools will continue to change. In other words, as the field looks ahead to the next thirty years and the future insights we may gain, researchers should continue to situate their investigations in robust, theoretically grounded perspectives in order to improve our understanding of SLA as well as develop effective, empirically motivated pedagogical materials (e.g., Chapelle, 1997, 1998, 2001). Continuing to build on the healthy body of work answering Chapelle's call to action, future research should extend Chapelle's (1997) guiding questions and instructional frameworks (1998, 2001) to explore how established and emerging technology-mediated tools can foster interactional processes supportive of SLA in new contexts and paradigms.

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Data Availability

Not applicable.

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