

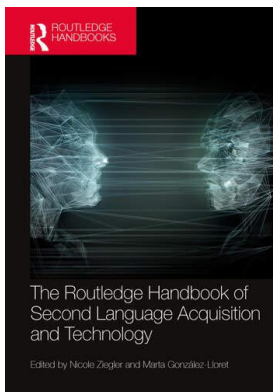
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SECOND LANGUAGE WRITING AND TECHNOLOGY

Rebecca Adams

Introduction

Writing is an area of language use that has continually evolved in tandem with technological developments. The early history of writing (c.f., Robinson, 2007) is replete with ways in which the development of technologies has impacted written communication, from the slate to paper to the typewriter. In each phase, new technologies have impacted the spread of literacy skills, styles of written communication, and the process of writing. The use of the internet to produce and disseminate writing, including social media and web 2.0 technologies, continues to influence opportunities both to engage in communication through writing and to compose in new ways. These tools have impacted second language (L2) writing, allowing learners to write to an expanded audience, and shaping the ways that language learners develop L2 writing skills and learn language through writing.

The end product of digital writing is digital texts. These are texts that are composed and distributed online. They are frequently multi-modal, communicating meaning to an audience through elements common in paper-based texts, like written language and images, with additional digital elements, including embedded gifs, video, and audio. Digital texts can be immediately disseminated to a real audience who can then interact with the text through commenting or adding and revising content, depending on the technology used. Vandergriff (2016) notes that the immediacy of the audience and level of interactivity in these technologies blurs the distinction between author and audience; the ability to connect and communicate with real audiences worldwide may also increase motivation for L2 writers (Li & Storch, 2017). While digital texts in earlier phases of the internet often closely resembled genres of paper-based communication (e.g., email is a digital version of a letter, a blog post is a digital equivalent of a journal entry), web 2.0 technologies (including social media and other collaborative technologies) have led to the development of digital texts without traditional equivalents. An Instagram story, for example, is a text composed of images and text, connected to similar content by hashtags, often with collaborative discussion among followers embedded. The knowledge and skills needed to effectively produce digital texts is referred to as digital literacy. Digital literacy encompasses the linguistic knowledge and writing skills associated with pen and paper writing as well as knowledge of technology tools and design knowledge developed from experiences both consuming and producing digital texts. Digital literacy skills include selecting both text and images, determining how to arrange them on the screen, following digital genre conventions, embedding objects, and using hyperlinks to support ideas and enhance communication.

Historical Perspectives

Technology and writing have always gone hand in hand, and indeed, as Reid (2008) points out, writing itself is a technology. Witte (2005) explains that “Any human act of doing or performing depends on a tool, a technology, or an artefact mediating between the acting participant . . . and the goal or object of the performance” (p. 143). Tools mediate our interactions with the world around us, and, as Haas (1996) suggests, transform both our environment and ourselves. Writing is an intrinsically tool-based activity, and the range of tools used in writing range from materials (pens, pencils, keyboards) to the symbolic (language itself). The use of a tool is not passive, but transformative; we use tools to write, but the tools we use influence the way we write and think about writing (Kern, 2015).

Early digital literacy work focused on the ways that technology could improve writing, such as decreasing errors or improving attitudes towards writing (Ching, 2018). Less research has considered how technology affects the process of composition; considering, for example, how writing via digital technology influences how learners read, plan, and develop a text (Haas, 1999). The limited research on the impact of online writing on learning has generally suggested that technology can positively impact L2 writing (Li & Storch, 2017). However, it should be remembered though that writing technologies are diverse and multifaceted. Technologies are not equal, nor are they passive. Rather, the tools we select influence the writing process. Conole and Dyke (2004) assert that digital writing technologies have drastically transformed the writing process. They note that with pen and paper, writing is a primarily linear process and the actual writing takes place towards then end of the process after ideas are generated and organized. Digital writing, on the other hand, allows for non-linear composition, allowing writers to add in and arrange ideas while drafting. It allows writers to easily build on and adapt past material, offering opportunities to reflect and revise as the writing emerges. Newer online technologies, including social media, allow for easy connections between text and non-text elements like images and emojis, increasing options for writers to create meaning.

Indeed, writers and scholars have claimed from the beginning of the machine-based writing era that the technologies we use to write impact both how and what we write (Kittler, 1999). For example, online writing has created new writing genres (e.g., texts, tweets, Insta-stories, eZines). Online writing formats have led to changes in how written language is used to communicate, with respect to page design, spelling and grammar, and the use of emojis and other multimodal elements (Coiro et al., 2008). Web 2.0 applications, including social media, have increased the interactivity of writing and opened avenues for communication and collaboration among writers and audience. The spread of new literacies necessitates empirical investigation into how L2 writers can best be taught to communicate through writing in an online era (Leu et al., 2013). Different technologies for writing provide different affordances (discussed below) that must be considered in the design, implementation, and evaluation of pedagogical activities (González-Lloret, 2017).

Critical Issues and Topics

Writing in L2 Learning

Studies of L2 writing have long been conducted from separate research perspectives. Bitchener and Ferris (2012) define these as a composition perspective, where the focus is on how to help language learners develop L2 writing skills, and a L2 acquisition focus, where research focuses on how the act of writing contributes to the language learning process. Cumming (1990) pointed out that as learners engage in literacy development, they also deepen their knowledge of language and gain opportunities to process linguistic structures not commonly found in oral communication. Research on technology and writing seeks to understand whether engagement with technology can both improve L2 writing skills and also promote language acquisition.

Research from multiple perspectives has implicated writing activities as ‘rich sites’ for language learning (Ortega, 2012). From a cognitive perspective, writing is one way that learners can engage in producing linguistic output, allowing them to notice gaps in their interlanguage knowledge, raising consciousness of linguistic forms (Swain, 2005). It also gives them chances to analyze their language use and apply knowledge that they have not yet mastered (Cumming, 1990). Some researchers have noted that writing, as compared to speech, may be particularly beneficial for learning it allows extra time for processing and increased ability to review and analyze production (Adams & Ross-Feldman, 2008). From a cognitivist standpoint, technology-mediated writing will promote language learning when it allows learners opportunities to notice and reflect on interlanguage gaps and make connections between form and meaning during the writing process.

Researchers working in a socio-cultural framework also focus on instances when learners use language as they attempt to solve linguistic problems, such as determining the best way to express a thought or trying to correct linguistic usage. These processes are referred to as collaborative dialog (Storch, 2013). Through this process, learners can build new linguistic knowledge or refine existing understandings. When learners engage in collaborative writing with peers, they can observe their interlocutor’s use of language when solving linguistic problems (as opposed to individual writing, where this mediation occurs through private speech; Storch, 2013). Collaborative writing therefore provides learners with opportunities to use language, to discuss language, and to observe others’ use of language to mediate learning. In technology-mediated settings, the ways that tools allow learners to communicate impacts how this collaboration unfolds and how it promotes learning.

In socio-cultural theory, the writing process is seen as a process of creation, which is shaped by social relationships in and beyond the classroom. In this view, all writing is collaborative (Rish et al., 2015). Prior (2006) notes that teachers, for example, function as a type of coauthor in their students’ writing, as instruction and feedback impact the identification of topics, the development of organization, and the linguistic means used to express ideas. Writing is a mediated process, meaning that writers use a variety of tools and resources, including language, which Vygotsky claims as the most important tool for shaping knowledge and experiences (Vygotsky, 1978). For technology-mediated writing, the technology is also a tool that mediates the learning process. Technological affordances, discussed below, can influence how learners write, and thus, how learning through writing unfolds.

L2 writing researchers also draw on Activity Theory, which derives from Vygotsky’s work as well, to understand learner participation in writing activities. In this view, writing is one type of activity system, a “goal-driven, historically situated, cooperative human interaction” (Russell, 1995). A key concept in Activity Theory is motive, defined as the desire or need that encourages a person to engage in an activity. Lantolf and Thorne (2006) point out that motives connect current actions with desired future outcomes. Storch’s (2004) study of L2 peer writing activities notes that participant motives shaped the ways that they engaged in collaboration, impacting whether they provided scaffolding to one another and how frequently they participated in collaborative talk, shaping the activity as a writing to learn language experience. Jin and Zhu (2010) point out that in technology-mediated writing, the technology itself can trigger and maintain motives; for example, a learner struggling to use the technology to communicate may develop a motive centered around developing digital literacy skills. Technology cannot be effectively used in L2 learning settings without careful consideration of how it supports language learning through writing.

Technological Affordances for Digital Literacy

Technological affordances refer to the potential uses of technology in different contexts (Bobsin et al., 2019). Designed, intended uses as well as creative, unanticipated uses of technology can be considered affordances (Conole & Dyke, 2004). For example, predictive text technology was

designed for mobile devices as a tool to ease the burden of typing on small touch screen keyboards. However, users of this technology use it in a variety of ways, for example, to aid in word retrieval, by typing part of a word and examining predictions, or as an aid in spelling unfamiliar words. Leonardi and Barley (2008) explain that affordances arise from the interplay between the technology itself and the characteristics of its users.

Technology cannot be used effectively to promote L2 writing outcomes unless its affordances are well suited to the specific learning needs and context. Smith et al. (2003) provided an early classification of affordances for L2 learners in terms of four key domains: temporality, identity/anonymity, modality, and spatiality, which have been broadly adopted in research on technology-mediated language learning. Studies of writing in technology-mediated settings have considered temporality, anonymity, and modality; research on these is discussed in this section. Temporality refers to the timing of communication online, in particular whether all communicators are online and interacting (synchronous) or whether communicators participate at different times (asynchronous). Temporality strongly impacts the ways that learners engage in and benefit from online collaborative writing. Synchronous collaborations lead to rapid exchanges of ideas and greater participation (Adams et al., 2015) while asynchronous collaborations lead to more careful consideration of message content and format as well as critical reflection on audience response (Zhao, 1998).

The second of the four domains, anonymity, refers to the extent to which a writer's identities are obscured or revealed by the technology. A high level of anonymity is associated with decreased inhibition in writing, with writers producing content that they might self-censor were their identities known (Herring, 1996), and lowered anxiety about making L2 errors in front of peers (Gharehbagh et al., 2019). For L2 learners, it can also be associated with an ability to position themselves as writers in a L2 context, influencing their identity construction in L2 spaces (Burke, 2013). As peer reviewers, L2 writers provide more comments and make more revisions based on comments from their peers in anonymous, online peer review as opposed to traditional, face-to-face peer review (Farahani et al., 2019). Anonymous reviewers also provide more feedback on higher order concerns, leading to more revision (Van den Bos & Tan, 2019).

The third domain of affordances, modality, refers to the communication channel used (e.g., voice vs. text) as well as use of non-text elements (including images and hyperlinks) in a digital text. Research on multimodal communication has focused on how these features can support the development of both literacy practices and language competencies. In L2 settings, research shows that the use of images and text are used to reflect both L1 and L2 identities (e.g., Lam, 2000). Multimodal writing is also associated with increased L2 writing motivation (Yi & Angay-Crowder, 2016), as multimodal communication reflects the ways that learners use technology to communicate beyond the classroom through social media. Learners who are encouraged to produce multimodal texts increase their L2 vocabulary and writing fluency (Miller et al., 2017) and produce more complex and lexically diverse texts (Vandommele et al., 2017), because the use of multimodal elements helps them to capture the meanings they wish to communicate, freeing attentional resources to focus on language use. Students in Elola and Oskoz's (2017) study also noted that including aural and visual elements when creating digital stories pushed them to consider new ways of organizing their narratives and conveying emotional meaning to their audience. The researchers conclude that the use of multimodal elements in digital writing in their study changed the way that students approached L2 writing.

Additional research on affordances related to modality has considered the mode of communication in peer writing, focusing on how synchronous communication among peers in either text or video channels impact the collaborative writing process. For example, Jones et al. (2006) examined learner interactional dynamics in face-to-face and online peer writing using a variety of web-based technologies for EFL writing. While interacting face-to-face, learners engaged more frequently in discussions on grammar, vocabulary, and style. On the other hand, when interacting online, they were more likely to address content and the writing process itself. These findings suggest that the

modality of the communication channel influences how peers approach writing, suggesting a need to match affordances of technology to the specific pedagogical focus of the writing activity.

Other researchers have considered affordances not included in the taxonomy proposed by Smith et al. (2003). For example, Woo et al. (2013) found that learners focused more on content than on language in wiki-based writing. The researchers suggest that this is related to key affordances of wiki, which they label as educational, social (collaborative), and technological affordances. For example, one technological affordance of the wiki environment, the spell-check function, eased learners' cognitive load, which then allowed them to attend more to the content of their writing. This research highlights that a myriad of technological and social factors beyond the key domains described above impact technology-mediated writing. Elola and Oskoz (2017) suggest that affordances associated with collaboration, collaborative authorship, and other social aspects of writing should be considered when determining how to employ technology in the writing process.

Considerations beyond affordances may also influence the effectiveness of technology in language learning settings. Chun et al. (2016) suggest that the sociolinguistic environment in which technology is used should be taken into account when selecting writing technologies. This includes the technology 'fit' for both teachers and students in the learning environment. For teachers, this means considering how the technology fits with the teacher's beliefs and preferences for writing instruction. A teacher interested in promoting individual student voices, for example, is likely to make limited use of a highly collaborative writing software like GoogleDocs. For students, it means considering how the technology fits with learner factors like age and educational background, as well as with learning goals and use of technology for writing beyond the classroom. Learner perceptions of the importance of writing as communication has increased, because writing (particularly through social media and other web 2.0 technology) plays an increasingly prominent role in the ways that learners socialize, share and access information, and develop their communication (Sweeney, 2010). Learners will struggle to recognize the relevance of writing instruction that does not include technology (Lenhart et al., 2008), or that does not align with the increasingly interactive and multimodal technology-mediated writing they do beyond the classroom.

Current Contributions and Research

The remainder of this chapter will focus on three areas of research that illustrate how technology offers unique opportunities for L2 writers. These three areas are (1) the use of technology to create and mediate collaborative writing experiences, (2) assessment of L2 digital texts, with particular focus on the use of automated writing evaluation (AWE), and (3) the use of corpora as a pedagogical tool in L2 writing.

Technology-Mediated Collaborative Writing

Recently, there has been a growing awareness among L1 and L2 composition scholars of the benefits of writing collectively with other learners to create a single text, as learners are able to receive and respond to critical responses to the text-in-progress from peers, promoting critical thinking about the text as an act of communication to an audience (Howard, 2010). Storch (2013) defines L2 collaborative writing as an "activity where there is a shared and negotiated decision-making process and shared responsibility for the production of a single texts" (p. 3). Research on collaborative writing has generally been influenced by sociocultural and activity theory perspectives on writing to learn, as collaborative writing integrates interactive communication with the composition process to uniquely promote language learning. Interactive Web 2.0 technologies have dramatically increased the ways that learners can collaboratively create texts (Li & Storch, 2017). Using wikis or cloud computing software like GoogleDocs, learners can collaboratively co-construct a text with

another learner in their classroom or one around the world. They can work with an individual they know to construct an essay, or they can edit, revise, and augment collaborative webpages created by people they have never met on Wikipedia and similar sites. A growing body of research explores how engagement in technology-mediated collaborative writing impacts (1) learner motivation and perceptions about writing, (2) how learners collaborate online and (3) how these collaborations support language learning.

Most studies have found that participants have positive attitudes towards asynchronous collaborative writing (e.g., Kost, 2011). Negative attitudes tend to be related to collaborative writing in general, rather than to collaborating online (e.g., Li & Zhu, 2013). Research on learner experiences in synchronous online writing have also been positive. In Bikowski and Vithanage's (2016) study examining collaborative writing using GoogleDocs during a semester long ESL writing course, students reported positive attitudes towards real time online collaborative writing. The researchers note that students who expressed negative opinions of using GoogleDocs tended to focus on collaborative writing (noting, e.g., that it's hard to merge ideas with a peer) rather than on the use of technology for collaboration.

In terms of how learners collaborate, learners have been found to vary in their approach to group writing, with some taking turns giving suggestions or acting as a scribe and others dividing up sections to write individually and then revise as a group (Cho, 2017). Learner interactional patterns can also impact engagement in collaborative writing online. While online asynchronous writing can promote mutual scaffolding that promotes language learning, not all groups of learners automatically work together in a collaborative manner. In addition, there are learner collaborative patterns that have only been found in online settings. In particular, researchers have described learners who withdraw from interaction in asynchronous collaborative writing. Li and Zhu (2013), for example, documented a 'dominant/withdrawn' pattern in a group where two learners grappled for control of the asynchronous task without responding to each other's contributions. The third learner contributed minimally and withdrew from the online record as each task advanced. Li and Zhu point out that, while a learner in a face-to-face group will feel pressure to contribute, it is much easier for a student to withdraw from an interaction online or to simply work separately, without acknowledging a peer. Cho (2018) found similar avoidance of interaction in synchronous discourse. Modality may also influence interactional patterns, with collaborative interactions found more frequently when learners use voice, rather than text, chatting to collaborate (Cho, 2017). Research on interactional patterns has consistently shown that online collaborative writing will not automatically lead to scaffolding and other interactional behaviors that promote learning.

Collaborative writing online can also differ in terms of how learners engage in discussion of linguistic form. For asynchronous writing, there is a tendency for learners to focus on content in collaborative writing (Kessler, 2009). However, researchers have documented evidence that learners can also attend to linguistic form when writing together online. For example, Arnold et al. (2012) found that when German foreign language students worked on collaborative wiki projects, nearly 40% of the revisions they made were related to language use. Mak and Coniam (2008) suggest that learners need time to become accustomed to the technological platform before they will begin to attend to form in collaborative writing, highlighting the need for careful selection of technology from the onset of instruction to avoid needing to change. This may be particularly important in collaborative writing, where learners are more likely to edit as they go compared to individual writing, where writers tend to draft and then edit (Elola & Oskoz, 2010). In synchronous collaborative writing, studies also indicate that learners engage in discussion of form, but not necessarily as often as in face-to-face collaborations (Rouhshad & Storch, 2016). Rouhshad and Storch suggest that although the online collaboration tool used (GoogleDocs) allows for synchronous communication, the learners may have focused more on the writing interface and on creating text than communicating about language.

Limited research has examined how online collaborative writing impacts writing quality. For asynchronous writing, studies have indicated that participants produce texts that are higher quality in terms of accuracy (Arnold et al., 2012), complexity (Mak & Coniam, 2008), and coherence (Kuteeva, 2011) than students produce in their individual writing. Elola and Oskoz (2010) tracked language discussion during the writing process to the final product, finding that students incorporated linguistic items discussed with peers. For synchronous collaborative writing, Woodrich and Fan (2017) found that ESL students working synchronously online in GoogleDocs produced writing that was rated lower by their teachers than students who collaborated face-to-face, despite exhibiting similar patterns of interaction between the modalities. They attributed this difference to difficulties in comparing ideas using the GoogleDocs chatting feature.

While many studies suggest advantages for collaborative writing over individual writing in online settings, some findings suggest that differences between online and face-to-face collaboration may limit the overall effectiveness of writing done online. Affordances of different online writing technologies will influence how learners collaborate, and thus the effectiveness of online writing, underscoring the need for careful consideration of technology used in L2 writing settings. It should be noted that, while interactive and multimodal web technologies have changed the ways that people write, the research on technology-mediated collaborative writing has largely been carried out in settings that closely resemble traditional, text only writing. Future research should consider how language learners make use of interactive and non-text features of online writing to create and communicate meaning.

Automatic Writing Evaluation (AWE)

Just as technology is creating new spaces and means of collaborative writing, it is creating new means for writers to receive and respond to feedback on their writing, in particular through AWE. AWE systems draw on areas of artificial intelligence, including natural language processing, pattern matching, and machine learning to differentiate writing of different quality, providing rubric-based summary feedback and line by line feedback on language use. Some well-known AWE systems, such as *Grammarly*, go beyond traditional spell and grammar checking to provide feedback on word selection, tone, and style. AWE systems have also been designed specifically for L2 speakers. One example is Cambridge's *Write & Improve*, which was designed specifically to allow English learners to practice and improve their writing. AWE systems generally give direct feedback by highlighting errors and providing learners with comments and suggestions for revisions. Some systems also include metalinguistic explanations.

There are three major strands of research in AWE: studies that examine whether the feedback provided by AWE platforms is reliable, studies that examine whether learners benefit from exposure to AWE, and studies that examine learner perceptions of AWE. Research on the reliability of AWE is designed to determine how much learners can trust the feedback they receive from an AWE system, generally by comparing AWE feedback with feedback given by native speaker raters. While several studies have found high correlations between computer-generated and human scores (Attali et al., 2010; Wang et al., 2012), other results included low positive correlations or even no correlation between teacher ratings and AWE (Li et al., 2014; Wang & Brown, 2007). These findings raise the possibility that human and computer raters do not rate writing quality in the same way.

Research on AWE has generally shown the students can use the feedback to revise their writing. Chapelle et al. (2015) found that students frequently ignore AWE, but when they use AWE to review, their revisions result in more targetlike usage. Further studies have shown that AWE feedback can help learners develop rhetorical competence (Huffman, 2015), that it can lead to improvement of the surface-level accuracy of their writing (Wang & Wang, 2012), and that it can raise awareness of discourse features (Chapelle et al., 2015). Different AWE systems promote learning in

different ways. Many AWE systems primarily give feedback on sentence-level grammatical issues, and so have little impact on global aspects of writing.

A larger body of research has considered how students experience AWE and their perceptions of its effectiveness for their writing. In general, studies have shown that L2 students find AWE to be helpful in improving their writing (Huffman, 2015), but value teacher feedback more highly (Hyland & Hyland, 2006; Yang, 2004), possibly because teachers respond more to meaning and ideas, whereas AWE tools give feedback mostly on lexis, grammar, and mechanics (Yang, 2004). Huffman (2015) notes as well that when students notice inaccuracies in the feedback given by an AWE platform, it diminishes their trust in the feedback and their overall view of AWE.

Corpora in L2 Writing

A further technology of interest in L2 writing is corpus-based tools. Corpora are machine-readable collections of text in a language. They can be developed for a specific genre of language (e.g., the News on the Web or NOW corpus) or general to a specific region or dialect group (e.g., the British National Corpus or BNC). Corpora are analyzed using programs that allow users to examine concordances (compilations of examples of words that surround a key word), collocations (common word groupings) and frequencies of words or phrasings. While corpora and corpus linguistics as a field of study predate internet technologies, web-based computing has allowed researchers to create corpora that are easily accessible online for language learners (Conrad, 2000).

For L2 writers, corpus-based tools offer access to examples of authentic text, allowing them to determine which of a group of synonyms is the best fit for the text they are writing, to use context clues to analyze words they frequently confuse (e.g., *bored* vs *boring*), or to disambiguate among different meanings of a single word (Klimova, 2013). Some corpora include tools specifically for writers. For example, the Corpus of Contemporary American English (COCA) allows writers to upload their own texts to see a frequency report on the words they have used and to check their phrasing with exemplars from the corpus, allowing them to verify whether their usage matches genre and register conventions (Conrad, 2000). Some researchers have also built corpora expressly to promote L2 learning and writing. Chen et al. (2015) created a paraphrasing tool based on a Chinese-English parallel corpus that allows students to enter strings of words and view paraphrase options in both languages. Their research showed that use of the tool improved student ability to paraphrase in academic writing.

Research on the use of corpora in L2 writing instruction has focused on learner perceptions of corpora use, the effects of corpora on the surface-level features of L2 texts, and the impact of corpora on discourse-level features of L2 texts. Generally, L2 writers have reported positive experiences when using corpus linguistics tools as part of the writing process, noting that it can help them improve their use of lexis and grammar (Huang, 2014). Research has also suggested that the use of corpora pushes learners to become more autonomous in their writing (Park, 2012) and less reliant on teacher help (Yoon, 2008). Multiple studies have found that the use of corpora improves sentence and phrase-level accuracy in L2 writing (e.g., Garner, 2013), but that effectiveness of the use of corpora depends on the type of linguistics errors that need correcting (Tono et al., 2014). Overall, research on the use of corpora in L2 writing instruction suggest that careful, teacher-guided use of corpora can improve the linguistic correctness of texts and also help learners develop critical writing strategies that increase autonomy in writing.

Main Research Methods

Because research on L2 writing and technology is quite multifaceted, a wide range of research approaches have been used. Research methods in technology-mediated writing studies have tended

to closely follow the methodology of face-to-face studies for comparability (e.g., Roushad & Storch, 2016). Collaborative writing studies both in face-to-face and technology-mediated studies, for example, tend to be descriptive studies, with researchers analyzing collaborative moves and linguistic and discourse features of the texts they produce (e.g., Cho, 2017; Li & Zhu, 2013).

Changes in technology have, however, impacted the design of writing studies. As Çiftçi & Aslan (2019) point out, research on writing has changed with technology changes, with the majority of earlier research focused on writing in wikis and blogs, and newer research considering writing in Google Docs, social media, and other web 2.0 applications. Newer technological tools are also creating opportunities for researchers to examine writing processes in unique ways. Two such tools are eye-tracking software and keystroke logging programs. Both of these are relatively unobtrusive means that give researchers insights to the writing process. With eye-tracking, researchers can examine, for example, how learners focus attention on different aspects of multimodal texts, attempting to understand the strategies learners use for managing resources while composing (e.g., Anson & Schwegler, 2012). Keystroke logging allows researchers a view into how learners draft and revise as well as evidence of how and when learners pause to reflect while writing. Révész et al. (2019), for example, used both keystroke logging and eye tracking, along with stimulated recall, in a study of pausing by L2 writers in an IELTS writing task. They found that different lengths of pauses were related to different cognitive processes; when learners paused for longer times, they looked further back in the text and reported thinking about global writing issues such as those related to organization and content. When they paused more briefly, their gaze was more closely focused on the place in the text where they had been working, and they reported focusing more on sentence-level grammar and vocabulary issues. As Galbraith and Vedder (2019) point out, using the newer research technology with more traditional data collection methods like stimulated recall allows researchers to examine learner actions during writing as well as the reasons for those actions.

Learner analytics is another tool that can give researchers insights into the writing process that was previously not accessible. Learner analytics allows researchers to capture, measure, and analyze data on learners and the learning context. The purpose of learner analytics is to better understand and optimize learning processes (Siemens & Long, 2011). AWE systems, for example, can collect data on how often and how long learners work on each stage of the writing process, as well as the errors they make and correct, and improvements in their quality of writing. Liu et al. (2017), for example, gave learners engaged in L2 collaborative writing access to data visualizations of their individual and group participation in drafting and editing their texts. Qualitative responses from the learners signaled that this information motivated them to engage more productively in their collaborations. Very little research has made use of learner analytics in L2 writing research, but this technology holds promise for better understanding of how learners write and make use of writing technologies including AWE and corpora in the writing process.

Recommendations for Practice

The growing body of research on technology and writing is beginning to provide guidance to teachers hoping to use technology effectively to build L2 writing competencies. The clearest recommendation is that a careful match is needed between the affordances of the technology and the learning needs and objectives of the students. Technology is not transparent; it impacts the ways that students engage with writing (Ching, 2018). Writing (through social media) has taken on an increased importance in casual communication beyond the classroom. Bringing technology that learners use beyond the classroom can motivate learners by helping them see the relevance of writing tasks; however, this can be undermined if the pedagogical aim is a poor match for the technology being used (e.g., Twitter may be a helpful technology for focusing on sentence level

grammar and word choice, but not for focusing on paragraphing, transitions, or other more global aspects of writing).

There are clear pedagogical implications as well for the use of the technologies discussed in this chapter. Technology-mediated collaborative writing leads to greater focus on linguistic accuracy than individual writing, and thus may be a good fit for writing practice when focus on linguistic form is the pedagogical objective, and can push students to engage in collaborative dialogue outside of classroom time (Arnold et al., 2012). However, not all learners will engage productively and collaboratively in writing online; learners may take a more passive role or they may simply disappear online (Li & Zhu, 2013). Collaborative writing assignments require teacher monitoring of both the process and the product to promote language learning through writing.

Based on current research, AWE and corpus tools can both be recommended for improving accuracy in sentence-level grammar (Wang & Wang, 2012). AWE may be particularly helpful at specific stages of the writing process (e.g., while revising for a final draft, after revisions on content and organization based on peer or teacher feedback have been made). Using AWE for feedback on some drafts or some assignments can allow teachers to increase the volume of student writing without a corresponding increase in time needed to provide feedback. The use of corpora can similarly be integrated into the writing cycle, particularly for adolescent and adult students. Following indirect feedback from a teacher, students can use corpora to understand and correct grammatical and word choice errors in their drafts (Tono et al., 2014). Students can also make use of corpora in consciousness-raising activities (e.g., to determine which cohesion markers are used in different genres of writing) as a means of improving writing (Yoon, 2008).

Future Directions

While the body of research on technology and writing is large, multifaceted, and growing, a few clear directions for future research emerge. Most studies of technology and writing take place over a short time period. Research that considers how learners use and learn from technological tools over longer terms is needed to understand the impact of technology on L2 writing. A substantial portion of the research on technology and writing has adopted qualitative approaches with small sample sizes. Larger studies have tended to use descriptive approaches. Both Yim and Warschauer (2017) and Li (2018) call for more quantifiable data collected from experimental studies to understand the relationship between technology and writing. In particular, studies with pre- and post-test designs to capture the effects of using different technologies on writing skills and language learning are needed. This should include studies of whether learners acquire new linguistic knowledge when writing with technology and whether they apply such knowledge in future writing as well as studies of what learners focus on and retain from receiving AWE or using corpora in their writing. Research technologies like keystroke logging and learner analytics can give researchers a more precise understanding of the composition process. For example, eye-tracking technology could be integrated into a study of AWE to help understand how learners focus their attention during writing in order to determine information (corrections, metalinguistic explanations) learners attend to when they receive AWE feedback.

Beyond expanding research frameworks, empirical studies from a wider variety of contexts are needed. Nearly all studies of technology and writing take place in ESL or EFL settings. Very little research has examined the role of technology in the development of languages other than English and few studies have been conducted outside of adult, academic settings. Research on the experiences, perceptions, and writing development of younger learners in a wider variety of settings is needed. In particular, researchers should consider how students use technology to write beyond the classroom, with research focusing on how social and educational uses of technology can be blended for language learning.

Further Reading

Cotos, E. (2014). *Genre-based automated writing evaluation for L2 research writing: From design to evaluation and enhancement*. Palgrave Macmillan.

This volume provides teachers and researchers with an overview of AWE and presents the model for designing corpus and genre-based AWE specifically for research writing that was the basis for the development of The Research Writing Tutor (an AWE program).

Ajimer, K. (Ed.) (2009). *Corpora and Language Teaching*. John Benjamins.

An edited collection of studies that demonstrates a variety of strategies that language teachers can use to integrate corpora and concordance tools into language teaching.

Heift, T., & Hegelheimer, V. (2017). Computer-assisted corrective feedback and language learning. In N. Hossein & E. Kartchava (Eds.) *Corrective feedback in second language teaching and learning: Research, theory, applications, and learning* (pp. 51–65). Routledge.

An extensive review of research on AWE and intelligent tutoring systems in second language learning contexts.

Kern, R. (2015). *Language, literacy, and technology*. Cambridge University Press.

A book-length treatment on the development of literacy and how changes in technology impact both how and what people write, with particular focus on the features and potential of digital, multimodal communication through writing. The final chapters present pedagogical principles for integrating technology into literacy education.

Li, M. (2018) Computer-mediated collaborative writing in L2 contexts: An analysis of empirical research, *Computer Assisted Language Learning*, 31(8), 882–904. <https://doi.org/10.1080/09588221.2018.1465981>

A state of the art article on technology-mediated L2 collaborative writing, focusing on the writing processes, written products, and learner perceptions.

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