

THE ROLE OF TECHNOLOGY IN SLA RESEARCH

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In this review article for the 20th Anniversary Issue, I look back at research from the last two decades on the role of computer technology in understanding and facilitating second language acquisition (SLA) and forward to what future research might investigate. To be discussed are both how technology has been used to conduct research on SLA processes and what the impacts of technology have been as a mediator of those processes. As we progress into the 21st century, I suggest that technology in SLA research will assume an increasingly greater role, approaching Bax's (2003, 2011) notion of *normalization* for the field of computer-assisted language learning, namely that technology is gradually being fully integrated into second language teaching, learning, and research. In addition, I propose that SLA research investigate not only the traditional aspects of linguistic and communicative competence but newer types of *symbolic competence* (e.g., Kramsch, 2011) and *intercultural communicative competence* (e.g., Byram, 1997), which include integral technological components, and which are a part of general *digital literacies* or *multiliteracies*.

Language(s) Learned in this study: Various

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INTRODUCTION

In the inaugural issue of *Language Learning & Technology (LLT)*, which intended to define the research agenda for the journal, all four articles addressed the question of how SLA research and CALL research could be fruitfully combined. Chapelle (1997) applied research methods for instructed SLA to CALL, focusing on the interactionist approach and discourse analysis to investigate CALL activities. She emphasized observing learners' linguistic and nonlinguistic interactions in such activities, particularly those aspects of interactions that advance SLA.

Based on theories of both L2 reading and learning with multimedia, Chun and Plass (1997) suggested a research agenda that focuses on investigating the cognitive processes involved in L2 reading. Of particular interest is how readers integrate the verbal and visual information presented when they are provided with multimedia aids for text comprehension. More generally, Chun and Plass proposed that "the primary research question is not whether multimedia instruction is effective, but rather under what conditions and for whom" (p. 72). This means that research should take individual differences into account in order to determine the effectiveness of specific features of computer-based materials for specific types of L2 learners, specific learning tasks, and specific cognitive processes.

The article by Ortega (1997) presented a research agenda for L2 computer-assisted classroom discussion (CACD) connected to SLA theory. She suggested that a multiplicity of data sources be used in order to document the processes learners actually engage in when carrying out CACD tasks in addition to analyzing language outcomes. Her proposal for a process- and task-driven research agenda sought to ascertain which features of CACD may or may not be relevant to the processes involved in SLA. She

noted that at least two aspects of production need to be separately investigated: first, the interlanguage produced over time in electronic discussions (using quantitative measures of syntactic complexity, lexical range, accuracy, and writing fluency), and second, interactional features of CACD discourse that are thought to be relevant in SLA processes (employing both qualitative and quantitative analyses).

Brown (1997) examined computer-assisted language testing and focused in particular on computerized-adaptive language testing (CALT), delineating the issues that CALT research needed to address as well as emerging related areas such as intelligent teaching systems, speech recognition, analysis and scoring of compositions, and alternative psychometric models for analyzing more complex computer-assisted responses.

Although the four inaugural articles were not intended to cover the entire scope of CALL, they form the starting point for this review article, which will explore how the ideas that were suggested have (or have not) been taken up in subsequent CALL research. The next section will summarize the ways in which technology has been used (a) to research SLA processes and (b) as a tool or mediator to facilitate SLA. It is followed by a presentation of what has been learned from selected seminal studies in CALL—particularly those from the last 20 years and those that have appeared in *LLT*. The final section suggests avenues and questions for future research.

TECHNOLOGY: BOTH A RESEARCH TOOL AND A MEDIUM FOR TEACHING AND LEARNING

One hallmark of the articles in *LLT* is that most of them address *both* the issue of how technology can be used to conduct SLA research and how technology serves as a tool or mediator of various types of SLA processes. This reflects what is one of the most compelling affordances of technology for SLA and CALL research, namely that computers (or any device containing a processor that does calculations and executes code, e.g., tablets and smartphones) inherently have the capacity to record user actions, input, and behaviors. Although computers may need to be programmed to sort and organize this information into a form that is accessible and usable to a researcher, the ability to keep records of what users write, say, and do while using technology provides researchers with data of both SLA *processes* and *products*. The next two sub-sections discuss these two different uses of technology, namely technology as a research tool and as a learning tool.

Use of Technology to Research and Understand SLA Processes

SLA research encompasses many different theoretical as well as methodological perspectives. Hubbard (2008), in reviewing 25 years of CALL research, specifically with regard to the term *theory*, determined that references to SLA theories were the most numerous in his corpus. Among SLA theories, 10 contemporary theories were presented by VanPatten and Williams (2015), and broadly speaking, much, but certainly not all, of CALL research can be positioned among four of the most commonly recognized theories and approaches: usage-based approaches, the interaction approach, Skill Acquisition Theory, and Sociocultural Theory. What these theories and approaches have in common is the importance of input and exposure to language and communicative contexts (the *linguistic environment*), as well as the focus on the cognitive and socio-cognitive processes of L2 learners (e.g., noticing and negotiation for meaning), as they interact in *social environments*. Technologies such as the Internet provide unprecedented access to world languages, and learners have exposure to a myriad of input types. Different technologies and programs can document the communicative processes such as various types of computer-mediated communication (CMC), eye-tracking, and Intelligent CALL (ICALL).

The capacity to track learner actions and behaviors is evident in the entire range of CALL research, from studies of how learners noticed or attended more carefully to information when using electronic dictionaries for vocabulary learning (Laufer & Hill, 2000) to studies of which types of multimedia glosses promoted noticing and led to better vocabulary acquisition or reading comprehension (Al Seghayer, 2001;

Chun & Plass, 1996; Yanguas, 2009). Computer tracking of user-behavior can provide insight into the construction of grammatical knowledge (Collentine, 2000). In a longitudinal study by Heift (2010), program logs of learner behavior were compiled over the course of three semesters as learners used a parser-based program that provided two different kinds of feedback. Results showed significant differences in learner uptake at the advanced level of proficiency, depending on the specificity of the feedback.

One of the most widely researched uses of technology, CMC, exists in different forms (asynchronous [ACMC] and synchronous [SCMC]), in different modes (text-based, audio-based, video-based, or some combination thereof), and for different purposes (from academic forums to purely social networks). Early CMC studies of computer assisted classroom discussion documented the development of interactive competence and compared CACD with face-to-face (FTF) conversations (Chun, 1994; Kern, 1995; Warschauer, 1996), while later studies of intercultural exchanges across continents focused on sociocultural aspects of telecollaboration (Belz, 2002; Chun, 2014; Furstenberg et al., 2001; Thorne, 2003).

The recording and storage capacities of different technologies allow researchers to analyze how students use various technological resources, whether to develop oral proficiency (Lys, 2013), to negotiate meaning using text-based SCMC (e.g., Blake, 2000) or using video and audio SCMC (e.g., Yanguas, 2010), to provide peer feedback (Ware & O'Dowd, 2008), or to develop e-politeness (Biesenbach-Lucas, 2007).

Text-based chat transcripts were found to be insufficient for documenting the entirety of what learners do or produce, leading Smith (2008) to propose an innovative methodology of using video-enhanced chatscripts. He demonstrated that by simply using the finished “product” of chat log files, much information about the “process” of chatting is neglected or ignored. His results are persuasive that fundamental differences in interpretation and conclusions are reached from the video-enhanced chatscripts. Similarly, Sauro (2012) compared L2 performance in text-chat and spoken discourse by analyzing both chat transcripts and video-enhanced chatscripts and found no significant differences in either lexical or syntactic complexity of the narratives in the two modalities. Instead, there was evidence that some learners generated more complex language predominantly in text-chat while others showed greater complexity in spoken discourse. Park and Kinginger (2010) employed digital video (screen recordings) to capture an L2 writer’s composing process, including corpus search queries, and provided an explicit representation of the learner’s cognitive processes.

A technology that is gaining influence in SLA research is eye-tracking technology. It has been used, for example, by Smith (2012) to study the construct of noticing by recording participants’ eye gaze while they were engaged in a short chat interaction task. Noticing events, specifically noticing corrective feedback provided by a native speaker in a SCMC setting, was operationalized by increased visual attention as shown in “heat maps” of the learner’s eye gaze. The heat map data was compared with the data from stimulated recall and both were highly and positively correlated with one another, leading Smith to conclude that the two methodological techniques used in conjunction with each other may help SLA researchers better understand the construct of noticing.

Other technologies, such as an Intelligent Language Tutoring System, can provide detailed, error-specific, and individualized feedback to learners. The empirical data of learner-controlled practice and error correction inform us about the impact of learner control on error correction (Heift, 2002). Technologies that compile corpora of native speaker and learner language can be used for SLA research, and collocation software or websites allow researchers to study how learners acquire collocations (Chambers, 2005). Recordings, either audio or video, of think aloud protocols can be used to study learner strategies or metacognitive processes (Yoon & Jo, 2014). An important learner variable, working memory, was measured using online tests of working memory in order to show the relationship between speaking tasks

and working memory (Payne & Ross, 2005).

[Appendix A](#) shows examples of different SLA theories and constructs, the technologies that were used to conduct the research, and sample research studies. The next section discusses how technology can be a tool or mediator in SLA itself.

The Impact of Technology as Mediator of SLA Processes

As seen in the section above, the SLA construct of the linguistic environment is critical for several SLA theories, especially the interaction approach and usage-based approaches. Technology, through the World Wide Web or Internet, allows for exposure to authentic target language input, in the form of multimodal websites that contain text-based, audio, and video information about both language and culture. In addition, the many different types of CMC, often classified as Web 1.0 and Web 2.0 technologies (e.g., email, forums, chats, blogs, wikis, podcasts, videos, social networking sites, virtual worlds, massively multiplayer online games) enable various kinds of communication, interaction, and collaboration, whether it be between learner and computer or between or among people (i.e., learners in and outside of the classroom or speakers of the target language anywhere in the world).

Golonka, Bowles, Frank, Richardson, and Freynik (2014) reviewed over 350 studies of the effectiveness of technology use in foreign language (FL) learning and teaching, focusing on empirical studies that compared the use of technologies with more traditional methods or materials. Despite the abundance of available publications, evidence of efficacy was found to be limited. Technology was found to have made a strong impact on FL learning in two areas: the use of automatic speech recognition (ASR) for pronunciation training and the use of chat for increasing language production and language complexity. Moderate support was found for technology providing intelligent feedback and enhancing learners' noticing, focus on form, output and interaction, vocabulary learning, speaking proficiency, and affect and motivation.

Technology allows for unlimited input and repetition (e.g., vocabulary tutors, see Groot, 2000), as well as for modifying input (e.g., slowing speech to aid listening comprehension, see McBride, 2011). For the development of grammar, mobile-assisted grammar exercises and their effect on self-editing in L2 writing have been studied (Li & Hegelheimer, 2013). Other studies of grammar examined student-initiated attention to form in wiki-based collaborative writing (Kessler, 2009) and focus on form in expert-to-novice CMC interaction (Lee, 2008). ICALL and corpus linguistic analysis were found to produce "a lasting improvement in L2 learners' ability to edit persistent grammatical errors from their writing" (Cowan, Choo, & Lee, 2014, p. 193).

According to the interaction approach, opportunities for interaction and negotiation of meaning are important for SLA. Blake (2000) documented how synchronous chat used with jigsaw, information-gap, and decision-making tasks promoted negotiations between dyad partners. Toyoda and Harrison (2002) examined different triggers for the negotiation of meaning during chat conversations, and Bower and Kawaguchi (2011) investigated the negotiation of meaning and corrective feedback in eTandem interactions.

Technology can be used to facilitate various SLA processes and skills. For example, ASR has been effective for pronunciation training (Hirata, 2004), as have multimedia displays that provide visual feedback of pitch curves (Hardison, 2004; Olson, 2014). For listening comprehension, captioned videos (Winke, Gass & Sydorenko, 2010) and subtitles and transcripts (Grgurović & Hegelheimer, 2007) have been helpful. L2 reading software with multimedia annotations have been shown to aid reading comprehension (Lomicka, 1998; Yanguas, 2009).

Technologies can enable new methods and approaches to learning and teaching. For example, they offer the possibility for reading to be a social (rather than an individual) process. Blyth (2014) explored the affordances of social reading for L2 literacy, and Jalkanen and Vaarala (2013) examined the literacy

practices of L2 learners when reading and writing blogs.

As Ortega (1997) suggested, many researchers have analyzed learner output in CMC based on SLA principles. For example, Sotillo (2000) examined discourse functions and syntactic complexity in two different modes of CMC—synchronous and asynchronous—finding that the quantity and types of discourse functions deemed necessary for SLA in SCMC were similar to those found in FTF conversations. In ACMC, discourse functions were more constrained than in SCMC, though the delayed nature of ACMC provided learners more opportunities to produce syntactically complex language. Sauro and Smith (2010) used video enhanced chatscripts of CMC to provide evidence of online planning and monitoring that led to greater linguistic complexity and lexical diversity.

For studies that investigated writing, Kessler, Bikowski, and Boggs (2012) found that students focused more on meaning than on form in collaborative writing for academic purposes. As Brown (1997) proposed, automated analysis of compositions has been studied (see Lavolette, Polio, & Kahng, 2015), and automated spoken response grading was investigated (see Crossley & McNamara, 2013).

In addition to using CMC for grammar development, writing and speaking, various forms of CMC have been used for the development of intercultural competence (Liaw, 2006) and pragmatics (Belz, 2003). But CMC is not a panacea for eradicating misunderstanding and preconceived notions about another culture, as Ware (2005) discovered.

Technology can help with the development of one's identity. For example, Kramsch, A'Ness, and Lam (2000) found that the electronic medium allows for the development of agency and identity. Klimanova and Dembovskaya (2013) investigated the development of identity using social networking tools, and Pasfield-Neofitou (2011) explored identity construction and what it means to be foreign.

A special issue of *LLT* on game-informed L2 teaching and learning positioned game and play as part of complex ecologies of practice (Reinhardt & Sykes, 2014). In Chik's (2014) contribution on autonomy and community, she analyzed rich data from gaming sessions, stimulated recall, focus group discussion, individual interviews, and online discussion forums. Allen, Crossley, Snow, and McNamara (2014) presented an intelligent tutoring system that provides students with explicit writing strategy instruction and practice, including a suite of educational games. They posited game enjoyment as key to engagement. Similarly, Thorne, Black, and Sykes (2009) revealed how freely chosen digital engagement in out-of-school settings, specifically, in Internet interest communities such as fan fiction sites, and in virtual environments and online games, allows for language socialization and sophisticated communicative practices.

Finally, when using technology as a tool or medium for SLA, research on individual differences and learner variables has indicated, for example, that not only can communication technologies increase direct access to language and literacy among deaf individuals, but that deaf adolescents who emailed or chatted more frequently exhibited higher reading comprehension skills in subsequent years (Garberoglio, Dickson, Cawthon, & Bond, 2015). Research by Plass, Chun, Leutner, and Mayer (1998) discussed how multimedia learning tools can accommodate visualizer-verbalizer differences.

[Appendix B](#) shows examples of specific SLA outcomes, the technologies that were used in the research, and sample studies. The next section discusses in greater detail the results of selected seminal studies.

SELECTED SEMINAL STUDIES

Based on the four-volume collection edited by Hubbard (2009) of seminal CALL studies published between 1988 and 2007 and on the most cited articles in the *CALICO Journal* and in *LLT* (excluding the ones featured in this special issue), excellent research has clearly flourished. I have taken the liberty of selecting a few seminal studies and meta-analyses that have caught my attention over the last 20 years.

These studies are by no means an exhaustive or comprehensive list but each of them demonstrates a particular principle that I would like to highlight in this review article.

In returning to the research agenda delineated in the inaugural issue of *LLT*, although technologies have changed, advanced, and evolved, many CALL researchers have grounded their investigations in SLA theories, with the interaction approach favored by Chapelle (1997) being one of the most commonly employed with a variety of research methodologies. For example, the study by Smith (2003) was grounded in the interaction approach. He found negotiation patterns in his CMC study that were similar to those observed in FTF communication (as in the model from Varonis & Gass, 1985). But he proposed that the model be expanded in order to be able to allow for a delay—sometimes a long delay—between the initial trigger and the indicator. This seminal study suggested that in CMC, turn-taking is different in that turns are not always adjacent to each other as they are in FTF conversation.

Multimedia learning has been a widely researched area, often following cognitive theories of learning with verbal and visual modalities (Chun & Plass, 1997). Many studies (e.g., Yoshii, 2006) showed that input in multiple modalities improved vocabulary acquisition while reading. Sydorenko (2010) examined the effect of input modality (video, audio, and captions) on vocabulary learning while listening, finding that the two groups that saw video accompanied by either audio + captions or captions alone learned more words than the group that only saw video with audio, but had no captions. However, the non-captioned video tended to improve listening comprehension. Similarly, Winke, Gass, and Sydorenko (2010) studied the effects of captioning during video-based listening activities for L2 learners of four different language and also found captioning to be more effective than no captioning.

In researching the use of multimedia for pronunciation training, Hardison (2004) conducted experiments using a pretest–posttest design to determine whether computer-based training that permits visual displays of pitch contours in real time would help in the acquisition of French prosody by American speakers. She supplemented the quantitative results with qualitative results of anonymous learner questionnaires, and both convincingly indicated the effectiveness of computer-assisted speech training.

In line with Ortega's (1997) proposal to research interlanguage produced over time and the interactional features of (text-based) CACD discourse that are relevant in SLA processes, Abrams (2003) studied the effect of SCMC and ACMC on oral performance, measuring lexical richness and diversity, syntactic complexity, and the number of idea units and words produced by L2 learners, finding that the SCMC group produced a greater increase in quantity of language than the ACMC and the control groups. However, in terms of quality of language, there were no significant differences among the three groups either lexically or syntactically. This study is notable because it represents CALL results that do not always demonstrate the superiority of technology-based tools but rather show that CALL is as good as (and in some ways better or worse) than “traditional” pedagogical mediators.

Newer technologies such as audio- and video-CMC have also been studied. Yanguas (2010) explored task-based, synchronous CMC and found that oral CMC groups do negotiate for meaning when speakers do not understand each other. However, there were differences in the way audio and video groups carried out the negotiations, due mainly to the lack of visual contact in the audio group. In addition, oral CMC turn-taking patterns were shown to be very similar to FTF patterns but opposite to those found in written SCMC.

An example of a study from a sociocultural perspective is one by Elola and Oskoz (2010) on collaborative writing in wikis and chats. Analysis of their data revealed that although statistically significant differences were not evident in terms of fluency, accuracy, and complexity when comparing individual and collaborative assignments, there were trends in how learners interacted while using the social tools of

wikis and chats.

Seminal studies on telecollaboration include those of Belz (2003) and O'Dowd (2003). Belz (2003) employed a case study approach to study linguistic perspectives on the development of intercultural competence in telecollaboration. Like many others, she based her analyses on Byram's (1997) model of intercultural communicative competence (ICC), examining the key moments in a seven-week email correspondence between German and American learners. In particular, she analyzed the linguistic features and patterns with respect to learner behaviors that Byram associates with the attitudes component of his model of ICC. In reporting on a year-long email exchange between Spanish and English university language learners, O'Dowd (2003) used qualitative methods to identify key characteristics of the exchanges that helped to develop learners' ICC. A variety of ethnographic techniques were used, such as participant observation, reviewing actual email data as well as emails from students containing feedback on the exchange, questionnaires and interviews with students, a researcher's reflexive journal, and feedback from a partner teacher.

A longitudinal study of L2 pragmatic development in study abroad by Shively (2011) is noteworthy because it employed technology and allowed a methodology beyond the traditional discourse completion tasks or role plays, typical of earlier pragmatics research. Participants in the study made naturalistic audio recordings of themselves as they visited shops, banks and other establishments and interacted with the native speakers. The data showed that students' pragmatic choices shifted over time, in part due to the process of language socialization and in part to explicit pragmatics instruction.

In summary, CALL research has expanded to include intercultural awareness and pragmatics learning in addition to the focus on linguistic interaction and development. The field is moving in the direction of considering language and culture learning in their broadest conception, namely as part of *digital literacies* or *multiliteracies* (Chun, Kern, & Smith, 2015; Hafner, Chik, & Jones, 2015; Kern, Ware, & Warschauer, 2004).

META-ANALYSES AND META-SYNTHESSES

One indication that a research area has arrived at a critical mass is that meta-analyses are conducted in order to look systematically at studies, identify patterns among the study results, and develop a more conclusive estimate of the magnitude of the effect of a particular variable. To date, a variety of meta-analyses have been conducted for CALL research. For example, Grgurović, Chapelle, and Shelley (2013) considered empirical research for a 36-year period from 1970-2006 on the effectiveness of pedagogies supported with technology for language outcomes versus pedagogies not supported with technology. In order to be included in their meta-analysis, studies had to measure performance on language tests, use an experimental or quasi-experimental design, and employ a pretest-posttest design or posttest design only. Overall results favored the technology-supported pedagogy, with a small but positive effect size. In other words, L2 instruction supported by technology was at least as effective as instruction without technology.

Felix (2008) reported on substantial data drawn from extensive studies of CALL effectiveness covering the period 1981-2005. She found that there was too much variety in terms of variables, settings, methods and technologies used to be able to ascertain overall effect sizes, but narrative reviews supported the findings that on the whole, there are positive effects of the use of technology in L1 and L2 learning. Specifically, technologies have the potential to engage students and create opportunities. Dedicated programs, such as glossing and visual annotations for word-learning, have been shown to be useful. Additionally, multimedia appeals to different learning styles, and "the use of technologies can have a positive effect on student attitudes and participation (although not reflected in higher achievement)" (p. 154). With regard to L2 writing, a positive impact on revision strategies was found, as well as the ability to switch between formal and informal language. On the negative side are concerns about technical

difficulties interfering with the learning process and the need for training in computer literacy for both students and teachers.

Similar to Felix's (2008) finding that glossing and visual annotations for L2 word learning are effective, Abraham (2008) determined in his meta-analysis that computer-mediated glosses had an overall medium effect on L2 reading comprehension and a large effect on incidental vocabulary learning. A meta-analysis by Yun (2011) found that *text + visual hypertext* glosses were moderately effective for L2 vocabulary acquisition when learners were assigned to *text-only* or *text + visual hypertext* glosses. In addition, multiple hypertext glosses are more helpful for vocabulary learning for beginning learners than for other proficiency levels. Other meta-analyses of the effect of glossing on reading comprehension revealed that computer-provided L1 glosses helped learners comprehend significantly more text than paper-based glossing aids, with a large average weighted effect size (Taylor, 2006, 2009).

In a meta-analysis of studies published between 1990 and 2012 of the effects of text-based SCMC on SLA, Lin, Huang, and Liou (2013) found a small but positive effect, indicating that text-based SCMC could be more effective for SLA than other means of communication. In addition, their findings suggested that intermediate learners might benefit from SCMC tasks if they are grouped in small groups or pairs and engage in weekly interactions. The meta-analyses of Lin (2014) and Lin (2015) also concerned CMC and SLA. The 2014 analysis of studies between 2000 and 2012 found a medium effect of CMC on SLA over FTF or no communication. Two variables were *not* found to be significant moderators: CMC mode (asynchronous vs. synchronous) and CMC modality (text-based vs. voice-based). The 2015 meta-synthesis reported on 59 studies between 2000 and 2012 and showed (a) a positive and medium overall effect for CMC when used for instructional purposes in SLA, (b) the largest effect for writing skills among the four language skills, and (c) smaller group studies produced a larger effect size than those using larger groups or no groups.

Sauro (2011) reported on a meta-synthesis of SCMC for SLA, operationalizing SLA as the development of Canale and Swain's (1980) four types of *communicative competence*. She found that 48 of 97 studies explored grammatical competence. Strategic competence was the next most investigated (31 studies), while 22 studies were performed on sociocultural competence and only 11 on discourse competence. She also noted that most of these studies were in response to Chapelle's (1997) advice to evaluate the quality of language and the effect of CALL on language learning.

However, a critical question can be posed: What counts as speaking and what counts as writing? In today's world, so much communication is done via writing, typing, and texting rather than speaking that the lines between writing and speaking are becoming blurred. Chapelle (2009) proposed that use of technology changes the nature of communicative competence theory:

Because learners communicate through technology, communicative competence needs to include the ability to communicate using readily accessible L2 technology aids (such as online bilingual dictionaries and tools that check grammar), the ability to make appropriate linguistic choices in face-to-face, remote, written, and oral modes, and the ability to choose appropriate technologies for communication and language learning. (p. 750)

The question SLA researchers must ask is how learners' access to new forms of input and new forms of CMC affect acquisition.

Finally, in a meta-analysis of research on computerized games and simulations in CALL, Peterson (2010) examined the underlying psycholinguistic and sociocultural constructs for using games and simulations for language learning in seven influential studies. Key findings of the studies included extensive target language (TL) use and collaborative TL dialogue, frequent instances of negotiation of meaning, and the forming of collaborative social relationships, all conducive to second language learning.

FUTURE AREAS FOR RESEARCH ON TECHNOLOGY AND SLA

In looking backwards, we see that technology has both enabled SLA research and enhanced L2 learning and teaching using a variety of theoretical and methodological approaches. In looking forwards, I propose adding a fourth stage to Warschauer's (2004) three stages of CALL (p. 22).

Table 1. *Stages of CALL*

Stage	1970s-1980s: Structural CALL	1980s-1990s: Communicative CALL	2000s Integrative CALL	2010s Ecological CALL
Technology	Mainframe	PCs	Multimedia and Internet	Mobile and wearable devices
English teaching paradigm	Grammar translation and audiolingual	Communicative language teaching	Content-based, English for Specific Purposes/English for Academic Purposes	Digital literacies, multiliteracies
View of language	Structural (a formal structural system)	Cognitive (a mentally constructed system)	Sociocognitive (developed in social interaction)	Symbolic and intercultural competence
Principal use of computers	Drill and practice	Communicative exercises	Authentic discourse	Global communication
Principal objective	Accuracy	Fluency	Agency	Identity as global citizens

A suggested name for the stage is *ecological CALL*, reflecting ecological perspectives of SLA (e.g., Kramsch & Whiteside, 2008; van Lier, 2004). This more encompassing view of language acquisition goes beyond classroom walls, as do technologies that can be accessed anytime and anywhere (e.g., mobile and wearable devices such as glasses and watches). In addition, suggestions to look beyond traditional definitions of *literacy* and to have as a goal *digital literacies* or *multiliteracies* (plural) abound (e.g., Kern, 2015, Lankshear & Knobel, 2011). The scope of language learning is also being extended beyond *communicative competence*. As one of the leading SLA scholars, Kramsch (2011, 2014) has revisited the notion of *third place* or *third culture* in light of global technologies and has suggested *symbolic competence* as a goal, which is “the ability not only to approximate or appropriate for oneself someone else’s language, but to shape the very context in which the language is learned and used” (2011, p. 664). Kramsch and Whiteside (2008) wrote,

In the late modern stance offered by an ecological perspective, symbolic competence is both semiotic awareness (van Lier, 2004) and the ability to actively manipulate and shape one’s environment on multiple scales of time and space. Symbolic competence in our view adds a qualitative metalayer to all the uses of language studied by applied linguists, one that makes language variation, choice, and style central to the language learning enterprise. (p. 667)

What this means for L2 learners, is that in addition to developing L2 grammar, vocabulary, and understanding pragmatics, they also need to acquire the cultural know-how for dealing with technologized forms of language, either as producers or interpreters of meaning. Digital technologies make possible new kinds of texts, allowing writing to be combined with audio, images, music and video in a single document. Language is now just one mode for making meaning among many others, and L2 learners must be able to make culturally-encoded connections between forms, contexts, and meaning in a variety of

mediums.

The landscape of multimodal technologies and digital literacies is constantly changing and evolving. In the last 20 years, *LLT* has published three special issues on the topic: “literacies and technologies” (2000), “electronic literacies” (2006), and “digital literacies” (2015). In the introduction to their special issue on “digital literacies and language learning,” Hafner, Chik, and Jones (2015, p. 1) “argue that what it means to learn a language—the kinds of skills and social practices that one must develop in order to be a productive member of civic society—has also shifted” and that two main research notions addressed in their special issue are (a) that new modes of reading, writing, and communication create new needs of language learners and (b) that globalized online spaces create new, multilingual contexts within which L2 learners can autonomously capitalize on learning opportunities. These issues go hand-in-hand with the need to research 21st century language learning, the development of symbolic competence, and becoming global citizens beyond the classroom.

As Bax (2003, 2011) has proposed for CALL, I suggest that both the fields of CALL and SLA are moving in the direction of so-called *normalization*. Normalization for CALL refers to a state where technology is fully integrated into second language teaching and learning and is no longer special or unusual, in the way that books, pencils, and blackboards were in traditional classrooms. Similarly for SLA, as so much of instruction as well as everyday life is being supplemented, changed, and augmented by technology, both SLA research and the process of SLA will continue to be supported by technology. For example, at a recent international CALL conference where the theme was task-based language teaching and learning (TBLT), Van den Branden (2015) noted how much tasks and technology go (seamlessly) together: what a learner is supposed to be able to do with language today has direct relevance to our 21st century world of technology. The volume edited by González-Lloret and Ortega (2014), *Technology-mediated TBLT*, is a case in point, and as in everyday life, where we are faced with a whole new set of real world tasks (e.g., sending email request, complaints, and refusals), L2 learners will also need to acquire the functional linguistic and intercultural skills to carry out communicative actions and interactions in the L2.

In addition, both SLA and CALL research has repeatedly touted the benefits of feedback, both implicit and explicit, and technologies are ideal mediators to provide intelligent and meaningful feedback (e.g., ICALL). *Learning analytics*, which is an educational pursuit into data science, can also be explored; it is “a process of gathering and analyzing large amounts of detail about individual student interactions in online learning activities” (New Media Consortium, 2015). This aligns with the suggestion of Chun and Plass (1997) that a primary research question is not whether technology-based instruction is effective, but rather under what conditions and for whom. The technologies for conducting learner analytics are being refined and may well be one of the features of so-called *Web 3.0* that have been forecasted and are emerging, namely that Web 3.0 technologies are *personal and portable*, in that they are individualized by taking a user’s previous actions to interpret and make connections and predictions with this information.

Finally, in contemplating the future, along with the need for more longitudinal studies, there is also a need for what Hubbard (2008) termed *native CALL theories*. In his review of 25 years of CALL theory and in a subsequent article (Hubbard, 2012), he pointed to an insufficiency in employing theories that do not take the unique properties of technology into account and called for working towards the creation of new theoretical domains, in particular, for CALL. This is a task still waiting to be accomplished.

APPENDIX A. SLA Theories and Constructs and Technologies to Study Them

SLA Theory or Construct	Technologies Used	Sample Studies
Interaction approach	CMC	Smith, 2003
Usage-based approaches	Speech and language technologies that provide explicit feedback, access to corpora and concordances, context-embedded examples for implicit learning	Ellis & Bogart, 2007
Skill acquisition theory	HyperCard program <i>Banzai</i>	Nagata, 1998
Sociocultural theory	Wikis, chat	Elola & Oskoz, 2010
Noticing, attention	Eye-tracking; multimedia glosses	Smith 2012; Yanguas, 2009
Interlanguage	CMC	Blake, 2000
Linguistic environment	Audio recordings	Shively, 2011
Role of instruction	Video chat	Lys, 2013
Individual differences/Learner variables: working memory	Online working memory test	Payne & Ross, 2005

APPENDIX B. Technology as Tool or Mediator for SLA Outcomes

Learning Outcomes	Technologies Used	Sample Studies
L2 Speaking	Oral chat (SCMC & APMC); oral chat (SCMC)	Abrams, 2003; Payne & Ross, 2005
L2 Listening	Subtitles & transcripts; video captioning	Grgurović & Hegelheimer, 2007; Sydorenko, 2010
L2 Reading	Hypermedia programs	Al-Seghayer, 2001; Yanguas, 2009
L2 Writing	Writing Pal (ITS + games); wikis & chats	Allen et al., 2014; Elola & Oskoz, 2010
L2 Pronunciation	Computerized speech lab, CSL + web-based annotation tool with video; signal/speech processing	Hardison, 2004; Warren et al., 2009
L2 Vocabulary	Computers, mobile phones; video, audio, captions; Internet reading program	Stockwell, 2010; Winke, Gass, & Sydorenko, 2010; Yoshii, 2006
L2 Grammar	ICALL + corpus analysis; wikis	Cowan et al., 2014; Kessler, 2009

L2 Pragmatics	Email; audio recordings	Biesenbach-Lucas, 2007; Shively, 2011
L2 Testing/Assessment	Automated scoring for speech; state of the art of CALT	Crossley & McNamara, 2013; Suvorov & Hegelheimer, 2013
Intercultural Competence	Forums; corpora-based e- referencing tools	Furstenberg et al., 2001; Liaw, 2006
Multiliteracies	Multimedia CD-ROM, chat; Facebook, YouTube comments, Wikipedia writing	Kramersch et al., 2000; Hafner et al., 2015

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