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5. TECHNOLOGY AND SECOND LANGUAGE ACQUISITION

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Computer technology provides learners with new and varied options for language learning through interactive tasks delivered through CD-ROMs, Web pages, and communications software on the Internet. Researchers need to reconsider any approach to second language acquisition (SLA) concerned with explaining how language development is prompted by exposure to the target language in view of the dramatic differences in language experience learners engage in due to computer technology. Virtually all theories are concerned with the role of linguistic input or the environment (VanPatten & Williams, 2007), and therefore technology needs to be considered.

This article describes three areas of intersection between information and communication technology and SLA. First, it illustrates how tasks developed through technology present opportunities for studying conditions for SLA by expanding characteristics of the learning tasks that researchers can design for learners. Second, it describes the use of research tasks for gathering a variety of data on learners' performance—data that reflect significant episodes of discourse (e.g., negotiation of meaning) and cognitive processes (e.g., noticing). Third, it outlines the influence of SLA in the pedagogy and research on computer-assisted language learning (CALL).

Computer-Assisted Second Language Research

Computer-assisted second language research (CASLR) tasks require learners to work on the target language interactively with a computer program or with other people through the medium of the computer. CASLR tasks may appear to the learners to be a regular part of instruction or assessment, or they may be introduced to learners as research tasks (Chapelle, 2001). Such tasks are used in SLA research to (1) operationalize learning conditions so researchers can test hypotheses about SLA and (2) gather data that allow the researcher to make inferences about learners' knowledge and strategies.

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1. Operationalizing Learning Conditions

As SLA researchers Larsen-Freeman and Long (1991) indicated, what is needed is an "applied research agenda to identify and assess the outcomes of psycholinguistically relevant instructional design features." CASLR is ideally suited for gathering evidence about the effects of such instructional design features. For example, a special issue of *Studies in Second Language Acquisition* (Hulstijn, 1997) included a number of such studies, in which CASLR tasks were developed to test instructional conditions such as the value of explicit versus implicit instruction (de Graaff, 1997). The degree of control over the instructional conditions in such research far exceeds what can be obtained in classroom research where teachers are to teach in a particular way.

As a consequence, a number of studies have tested precise hypotheses about SLA under pedagogical conditions. For example, Abraham (1985) investigated how inductive and deductive grammar presentation and practice interacted with individual differences in English as a second language learners' cognitive style. Doughty (1991) tested the effects of carefully varied input conditions for the acquisition of relative clauses in reading contexts. Sanz and Morgan-Short (2004) tested the effects of conditions varying in the presence or absence of grammar explanation and explicit feedback on the acquisition of Spanish word order. In short, for over 20 years, CASLR tasks have proven to be a reliable source of data about some aspects of instructed SLA. The selection of participants, control of conditions, assessment of individual differences, and testing of outcomes that can be done in such experiments are conducive to providing a stable basis for theory.

New types of language-learning tasks afforded by technology expand the options that teachers and researchers have for developing second language (L2) tasks for learners, and pedagogical CALL tasks contain some of the conditions of interest for SLA such as enhanced input (Plass, Chun, Mayer, & Leutner,1998; Yoshii & Flaitz, 2002), a variety of feedback (Nagata, 1993), types of help (Peters, 2007), and written interaction (Blake, 2000). As a result of the expanded set of task characteristics afforded by technology, SLA researchers might reconsider the analytic categories used for studying tasks beyond cognitive and interactional ones (Pica, Kanagy, & Falodun, 1993; Skehan, 1998) to include mode and location, for example (Chapelle, 2003).

2. Assessing Learners' Knowledge and Processes

SLA researchers use many different methods to collect data on learners' performance from asking them to judge the grammaticality of a sentence or the existence of a word to asking them to engage in interaction with another learner. Gass and Mackey (2007) pointed out that the choice of research tasks depends on the questions to be investigated. When questions concern examinees' reaction time, or performance on a carefully sequenced task, the obvious choice for data collection is

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the computer (e.g., Hagen, 1994), and such data collection procedures are often borrowed from psycholinguistic research in psychology departments (Hulstijn, 2000).

These and other CASLR tasks allow the researcher to make inferences about aspects of learners' language ability and learning processes (e.g., vocabulary, metacognitive strategies). In other words, such behaviors are used as evidence for what the learner knows and how the learner approaches the learning task (Mislevy, 1996). For example, learners' requests for vocabulary help may signify instances of noticing (Hegelheimer & Chapelle, 2000). The idea that such behaviors in online learning can be used as evidence for assessment inferences is powerful in combination with the reality that learners work on interactive CALL tasks that have the capability for capturing and systematically summarizing relevant evidence (Hulstijn, 1993).

Constructs for which SLA researchers might seek evidence in recorded behavioral data include individual cognitive attributes and processes as well as social dimensions of interaction patterns, or a combination of the two. In terms of cognitive individual differences, Chun and Payne (2004) found that the learners with lower verbal working memory capacity tended to use the built-in dictionary functions to look up more words. Might this variation in individual difference be revealed by lookup and other behaviors online? Data obtained during online social interaction can be interpreted descriptively—that is, to demonstrate what language and communication strategies were used on a given occasion or to show learners' development of performance over time (Belz & Kinginger, 2003; Negretti, 1999). However, an important research question is to what extent such data warrant more stable inferences about the status of language learners' abilities in contexts where they are using language through interactive technology (see Chapelle, 2003, chap. 4).

SLA and CALL Pedagogy

The conceptual leap between CASLR tasks and pedagogical tasks is not great. Indeed, research and practice in CALL demonstrates the utility of concepts from SLA for research and development of CALL. As Doughty (1987) pointed out, instructional designers desperately need foundations to help them make some of the many decisions they are faced with in designing or selecting software for classroom learning tasks. Moreover, researchers need perspectives that can help them to evaluate learning through CALL. Pica's (1997) assertion that theory and research motivated by cognitive and social perspectives to SLA are relevant to language instruction is nowhere illustrated as clearly as in CALL.

In the late 1990s, CALL pedagogy was being framed in terms of perspectives from SLA. Egbert, Chao, and Hanson-Smith (1999) introduced their edited collection on CALL pedagogy around conditions that SLA theory suggested were important for creating good learning opportunities. They argued that "before talking about the use of technology in language classrooms, we must talk about how additional languages are learned (p. 2). Chapelle (1998) suggested ways that CALL tasks can engage learners in interaction that helps them to make essential connections between form and

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meaning. Drawing on hypothesized benefits of interaction (Gass, 1997), she outlined the aspects of instructional design that would ideally be built into CALL tasks. Based on theoretical hypotheses about how acquisition is promoted through exposure to language, recommendations can be made for learning materials such as the following:

- Make key linguistic characteristics salient by highlighting and providing opportunities for repetitions and modifications for particular forms.
- Support modified interaction between the learner and the computer by providing the learner with control over when to request help, modify responses, and get access to repetition and review (Chapelle, 1998).

Doughty and Long (2003) drew on SLA to outline methodological principles of task-based language teaching that can be developed through technology-supported pedagogy. The principles encompass learning activities (e.g., use tasks, not texts, as the unit of analysis), input (e.g., elaborate input), learning processes (e.g., provide negative feedback), and learners (e.g., individualize learning). These types of methodological principles are critically important for teachers and researchers to make judgments about the quality of CALL tasks (Jamieson, Chapelle, & Preiss, 2005). Such judgments about the extent to which CALL tasks adhere to hypothesized opportunities for language learning define a good starting point for empirical research on CALL.

SLA and CALL Research

Researchers have found that cognitive interactionist and sociocultural SLA theories offer a means of interpreting prior research on CALL and suggest a point of departure for designing future studies of CALL activities that are based on human–computer interaction and computer-mediated communication.

1. Human–Computer Interactions

Table 1 summarizes research investigating instructional design strategies that can be interpreted through a cognitive interactionist perspective because of the help that the software provides for the learners' comprehension of aural or written input or the feedback it provides. Help with comprehension, in interactionist terms, provides modified input, helps make the input salient, potentially resolves miscomprehension, and prompts noticing.

In studies by Borrás and Lafayette (1994) and by Guillory (1998), the software provided L2 subtitles and keyword support that offered learners some input modification through the presentation of input in two modes. In such cases, if learners attempt to comprehend the aural input through listening, and refer to the written text only as needed, this support in some cases should modify the aural input and aid comprehension. In the study by Grace (1998), help in the form of first language (L1) translation and multiple forms of annotations for vocabulary would also be expected to provide modified input, resolve miscomprehension, and prompt noticing. In studies by Chun and Plass (1996), Jones and Plass (2002), and Plass et al. (1998), learners

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Table 1. Research investigating instructional design strategies interpreted through cognitive interactionist SLA

Instructional Strategy	Focus of Research	Cognitive Interactionist Interpretation	Outcome Consistent with Theory?
(1) Offering help for comprehension of aural input through written L2 support	Video input with L2 subtitles (Borrás & Lafayette, 1994)	L2 subtitles might provide modified input.	Yes
	Help with comprehension through L2 subtitles and with keywords (Guillory, 1998)	Both types of help would provide modified input, and the keywords should make particular linguistic forms salient.	Yes
(2) Offering help for comprehension of aural input through L1 support	Help with lexical and sentence interpretation with sentence-level translations (Grace, 1998)	Sentence-level help would provide modified input and prompt noticing.	Yes
(3) Offering help for comprehension of written input with multiple supports	Reading texts with help for vocabulary with multiple forms of annotations (Chun & Plass, 1996)	Multiple forms of help might make input salient and provide modified input.	Yes
	Help with vocabulary in listening with verbal and visual annotations (Jones & Plass, 2002)	Multiple forms of help might make input salient and provide modified input.	Yes
	Help with vocabulary in reading with multiple forms of annotations (Plass, Chun, Mayer, & Leutner, 1998)	Multiple forms of help might make input salient and provide modified input.	Yes
(4) Offering precise explanatory feedback on errors	Informative feedback on linguistic errors (Nagata, 1995)	Informative feedback would provide an opportunity to notice gaps and correct errors.	Yes

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were provided multiple forms of modified input as aural input, translations, images, and video. Any of these would be expected to serve in providing valuable modified input and resolving miscomprehension, as well as prompting noticing and deep processing of input.

The study by Nagata (1995) investigated software that provided informative feedback that learners were given in response to errors in their production. Such feedback would be expected to prompt their noticing of gaps in their linguistic knowledge and help them to correct their production. In short, these aspects of instructional design in CALL can be construed as creating opportunities for beneficial interactions and even a highly structured form of negotiation of meaning as learners control the input and its various modified forms. Learners can play the video, or scroll down the screens of written text, but when a comprehension breakdown occurs, they can stop the normal flow of comprehension to review, repeat, or ask for help. The construct of negotiation of meaning as developed in SLA research has also been studied in research investigating computer-mediated communication.

2. Computer-Mediated Communication

Modeled on SLA research on face-to-face communication, studies of computer-mediated communication (CMC) are concerned with the types of interactions that learners engage in, and in some cases, the effects of CMC tasks. Some researchers have investigated the written interaction among L2 learners working on CMC tasks to determine whether or not negotiation of meaning is evident. For example, Blake (2000) assigned jigsaw tasks, requiring learners to piece together a solution by sharing information each possessed, and decision-making tasks, requiring learners to make a decision based on shared information. In the data consisting of their online conversation, he looked for instances of negotiation of meaning, such as the one that appears in the following dialogue:

Student A: Cuales son en común? [What are in common?]
Student B: como se dice común en ingles? no comprehende. [How do you say "common" in English? no understand.]
Student A: común es cuando algo y una otra algo son el mismo; entiendes mi explicación? ["Common" is when something and another thing are the same; do you understand my explanation?]
Student B: si, gracias. . . .[Yes, thank you. . . .]

In a number of studies such as Blake's, researchers have found negotiation of meaning in the tasks that learners complete using Internet communication tools (ICTs). The results suggest that similar positive findings can be found in such tasks as those found in communication tasks that take place through face-to-face conversation. In addition, however, such research investigating written interaction has found that when learners communicate in writing, another type of negotiation can also appear—negotiation of form. For example, transcripts of the written interaction of learners of Spanish have found that conversations taking place in writing can exhibit a

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closer attention to form and self-correction such as the following one from a study by Pellettieri (2000).

G: Es tu hombre tiene una corbata y los anteojos? [Is your man wearing a necktie and glasses?]
R: Si, el tiene. [Yes, he is wearing.]
R: Si, el los tiene. [Yes he is wearing them.]

Moreover, oral communication over the Internet for completion of L2 tasks can result in a combination of oral and written modes mixed in a way that uses the writing to support aural comprehension and expression (Sauro, 2001). All of these findings suggest the potential utility of Internet conversations for language learners as well as for SLA researchers who are interested in studying the episodes of interaction that have proven to be of interest in face-to-face conversations.

Table 2 summarizes some recent studies of CMC for SLA. The first two studies investigated online communication tasks to determine the extent to which task negotiations affected retention of vocabulary (De la Fuente, 2003; Smith, 2004). Fernández-Garciá and Martínez-Arbelaiz (2003) found that in communication with native speakers of Spanish, the communication breakdowns and negotiation that learners experienced was primarily during the oral communication rather than in text chat. Jepson (2005) compared L2 learners' repair moves in synchronous text chat rooms and in voice chat rooms on the Internet. Voice chat generated more repair moves and moves associated with negative feedback consisting of recasts, explicit feedback and questions, as well as uptake consisting of incorporations of feedback and self-corrections.

Blake's (2000) study, mentioned earlier, investigated online text-based communication tasks in accordance with those designed by SLA researchers (Gass & Varonis, 1985) and looked for three moves in the negotiation of meaning sequence: the trigger, which was the language that causes miscommunication, the indicator; which is provided to signal that the miscommunication has occurred and the flow of conversation should be interrupted; and the solution, which resolves the miscommunication. Examining negotiation of meaning this way, Blake compared different types of tasks, finding that the jigsaw tasks in CMC, like those in face-to-face communication tasks, seem to best prompt negotiation of meaning. He characterized the process of completing the CMC tasks as an opportunity for the learners to "heighten their metalinguistic awareness of where they are in their own L2 vocabulary development and where they still need to go in order to gain more targetlike lexical control" (Blake, 2000, p. 133).

The following four studies (6–9 in Table 2) were conducted using the descriptive research methods of focused discourse analysis from SLA research. Pellettieri (2000) developed tasks that research on classroom SLA had found to be successful in promoting negotiation of meaning, and form, as mentioned above. Fernández-Garciá and Martínez-Arbelaiz (2002) investigated whether negotiation of meaning would take place in the text chat discussion among third-year university

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Table 2. Studies of computer-mediated communication

Aspects of interaction investigated	Results
(1) Negotiation of meaning (De la Fuente, 2003)	CMC and oral face-to-face interaction were equally effective for vocabulary learning, except for oral production of words for which oral face-to-face was better.
(2) Negotiated interaction (Smith, 2004)	Lexical items that were negotiated in online communication were more likely to be retained.
(3) Negotiation of meaning (Fernández-Garciá & Martínez-Arbelaiz, 2003)	Oral communication with native speakers resulted in more communication breakdowns and negotiation, but communication among nonnative speakers was relatively free of breakdowns.
(4) Repair moves (Jepson, 2005)	Voice chat generated more repair moves than text chat; clarification requests were the most frequent.
(5) Negotiation of meaning (Blake, 2000)	Similar to face-to-face communication tasks, the jigsaw tasks produced more negotiation of meaning episodes.
(6) Negotiation of meaning and form focused interaction (Pellettieri, 2000)	Negotiation of both form and meaning; learners self-corrected and corrected each other; task affected the quality of negotiation.
(7) Negotiation of meaning (Fernández-Garciá & Martínez-Arbelaiz, 2002)	Negotiation of meaning does occur, but indicators of misunderstanding are more frequently explicit than in oral conversation.
(8) Negotiation strategies (Lee, 2001)	Learners used meaning-focused communication strategies similar to those in face-to-face conversations, with little attention to form and correctness.
(9) Negotiation of meaning (Blake & Zyzik, 2003)	Negotiations were similar to those found for L2 learners; they focused mostly on vocabulary.
(10) Negotiation of meaning (Kötter, 2003)	Learners used more requests for a clarification, elaboration, or reformulation of partners' ideas than previously found in face-to-face communication tasks.

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students studying Spanish. Also, drawing on negotiation of meaning as it was operationalized by Gass and Varonis (1985), they found some instances of negotiation in the text chat conversations of learners as they discussed questions about readings, but the researchers also found more instances of resolution of communication breakdown through the use of the L1 than they felt was ideal. Investigating intermediate Spanish learners' use of negotiation in synchronous text CMC, Lee (2001) found a variety of strategies for resolving communication breakdowns including a small percentage of L1 use. Overall, she concluded that the learners used negotiation effectively for meaning-focused communication, but negotiations did not help them to use grammatically correct language because of their primary focus on meaning.

Two other studies have made similar findings about focus on meaning to the neglect of grammatical language and about L1 use. Blake and Zyzik (2003) hypothesized that CMC conversations between heritage speakers of Spanish (i.e., those who have some knowledge of Spanish from their family background) and L2 learners of Spanish would exhibit some of the advantages that interactionist theory posits for conversations between expert and novice speakers. They found that the heritage learner-L2 learner pairs engage in the same types of negotiation routines (e.g., "clarification requests, expansions, recasts, self corrections") as learner pairs (p. 538), and that these focused on lexical items for the most part, with many syntactic errors going unnoticed. The heritage learners provided more help for the Spanish L2 learners than the L2 learners provided for the heritage learners, but both took the roles of resolving communication breakdowns.

Kötter (2003) examined negotiation of meaning in synchronous written chat between German learners of English and American learners of German as they worked collaboratively on a project that was to be presented at the end of the semester. He found many instances of negotiations that were similar to those found in prior studies of face-to-face communication, but in addition, he found many more instances of code-switching.

Investigation of interactive written communication has also prompted researchers to look at the discourse from different perspectives—beyond what is typically used in task-based language research. Differences in communication prompt discourse analysis of L2 CMC to expand the scope of inquiry to examine phenomena such as L2 play (Warner, 2004) and other contextual factors that affect the amount and quality of interaction in online communication (Belz, 2001). In short, the new pragmatic contexts created through the use of ICT afford new opportunities for studying the communication that L2 learners engage in and identifying episodes within the communication that may be important for SLA.

Directions for Research

In view of the ubiquity of technology in the lives of language learners and all language users, the integration of technology with theory, research, and practice in

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SLA needs to be increased. This need might be addressed with research in three broad areas.

1. Expand SLA Theory and Research

Some SLA researchers have used computer technology to operationalize learning conditions and assess learning to test hypotheses about SLA, but the implications of technology for research and theory in SLA remain absent for the most part. Examination of the technology–SLA interface underscores a point that is being made by some SLA researchers—that the study of SLA requires a more detailed consideration of contexts of language development (Ortega, 2005). CALL expands how L2 tasks can be constructed and investigated in the L2 classroom. Tasks based on learner–computer interaction offer precise, accurate, and multimodal modified input upon request or according to a particular pedagogical design. Such task features provide a means of grounding CALL research in the same domain as classroom research-based L2 pedagogies. At the same time, CALL research provides a means of investigating various operationalizations of constructs such as interaction, which can refer to both human–computer interaction or CMC among learners (Chen, Belkada, & Okamoto, 2004).

However, the SLA–technology connection only begins with laboratory and classroom experiments that test conditions for second language acquisition. It extends to issues such as how to define second language ability as including (1) the ability that can be displayed with the help of readily accessible L2 technology aids (such as online bilingual dictionaries and grammar checkers); (2) the ability to make appropriate linguistic choices across a range of face-to-face, remote, written, and oral modes; and (3) the ability to choose appropriate technologies for communication and language learning. Technology dramatically extends and changes the breadth and depth of exposure that learners can have with the target language. As a consequence, all approaches to SLA that theorize a role for input need to consider the way that technology changes linguistic input and how learners access to new forms of input might affect acquisition.

2. Increase the Effectiveness of Assessment for Learning and Research

The capacity of technology for providing systematic, appropriate instruction to language learners has barely been tapped. Advances that take advantage of the computer's capacity for adaptive instruction require research that seeks to use principles of diagnostic assessment, student models, and natural language processing (NLP) to document learners' performance precisely, store relevant information, draw appropriate inferences, and take action for future instruction.

This process, which seems to be intuitively logical, is stymied by imprecise professional knowledge and underdeveloped technology for language analysis and inference. For example, how can useful areas of diagnostic information be selected by material developers? How can reliability of diagnostic inferences be achieved and monitored? How can diagnostic feedback be communicated to language learners? How can learners' language performance be summarized and stored for subsequent

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use? What evidence suggests that language learners are able to use and benefit from diagnostic feedback? What evidence suggests that learners benefit from the feedback and adaptivity afforded by NLP? How can adaptive learning paths be set to individualize learning effectively? Surprisingly little progress has been made to address these critical issues aimed at improving instruction in ways that are different from what can be accomplished with a teacher in front of a large class or by student–student conversation.

3. Incorporate SLA into CALL Design and Evaluation

At one time it was difficult for CALL researchers to find guidance from theory and research in SLA for CALL instructional design. Despite the variety of approaches toward SLA, little of the theory and research pertained to instructed SLA. Today, in contrast, research on learner–computer interaction and CMC demonstrates the utility of SLA for framing research questions and interpreting results. Theory posits cognitive processes fostering acquisition as well as how these processes are engaged through input that a task designer can manipulate. Theory also provides a means of examining collaboration in CMC (Gutiérrez, 2003). Tasks of theoretically pedagogical value can therefore be designed on the basis of principles. Work in this area, however, is only beginning to explore the relevant task characteristics in CALL tasks and the value of collaboration. Such research faces many of the challenges of classroom research, including navigation of the variety of classroom and distance learning contexts in which students learn language today.

Conclusion

The changes in language learning, assessment, and research afforded by technology are significant, far-reaching, and complex. Moreover, these changes are unlikely to diminish; on the contrary, the march of technology throughout all aspects of the lives of language learners is expanding whether it be through formal education or in their everyday lives. Such environments, of course, are of interest not only because of the resources they offer researchers, but also because they represent the context in which a great many language learners are studying language today. As a consequence, research identifying support for methodological principles in CALL holds the potential for directly influencing pedagogy for many learners.

Years ago it was necessary to argue that the design and evaluation of CALL could be strengthened by drawing on perspectives and methods from SLA (Doughty, 1987; Chapelle, 1997). Today, the productivity of SLA perspectives for CALL is an argument made easily (Kitade, 2000). It is made through the many examples of CALL research and development that explicitly draw on SLA as a basis for design and evaluation even though CALL can be studied from a variety of perspectives (Egbert & Petrie, 2005; Levy & Stockwell, 2006; Thorne, 2003; Warschauer, 1998). Today, the argument is being made for more technology-sensitive perspectives on SLA—perspectives that encompass hypotheses about the ubiquitous and varied target language contact learners have through technology as well as conceptions about technology-assisted language use and acquisition.

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ANNOTATED REFERENCES

Belz, J. A. (2003). Linguistic perspectives on the development of intercultural competence in telecollaboration. *Language Learning & Technology, 7*(2), 68–117.

This is a fascinating example of the use of linguistic data analysis in a principled manner to seek evidence of a construct of interest for foreign language teaching—intercultural competence. The analysis focuses on the linguistic realization of appraisal in the learners' language during CMC conversations. From a systemic functional perspective, appraisals are evident in the attitudes expressed through the interpersonal functions of language that are evident in expressions such as "I suppose that. . . ." versus "I know that. . . ." These are related to intercultural competence, Belz argued, because they reveal learners' beliefs about themselves and other cultures.

Chapelle, C. A. (2005). Interactionist SLA theory in CALL Research. In J. Egbert & G. Petrie (Eds.), *Research perspectives on CALL* (pp. 53–64). Mahwah, NJ: Erlbaum.

This article discusses the meaning of interaction and interactivity in CALL tasks and how these concepts used in CALL research and practice are connected to interactionist theory in SLA. It summarizes the research on CALL that can be interpreted in view of tenets of interactionist theory and demonstrates the utility of such a perspective for framing investigations of CALL.

Chapelle, C. A. (2003). *English language learning and technology: Lectures on teaching and research in the age of information and communication*. Amsterdam: Benjamins.

This book argues that the study of applied linguistics and technology requires teachers and researchers to step back from the obvious to reconsider the assumptions underlying popular, commonsense perspectives. It argues that significant, focused work needs to be undertaken if sophisticated software for language learning and assessment is to become the new reality in the future, and it demonstrates how existing conceptual tools from applied linguistics need to be engaged and expanded to make progress.

Doughty, C. (1991). Second language instruction does make a difference: Evidence from an empirical study of SL relativization. *Studies in Second Language Acquisition, 13*, 431–469.

This classic study by Doughty (1991) illustrates how computer technology can be used to design precise experimental treatments to test hypotheses about SLA with classroom learners. Investigating relative clause acquisition by ESL learners, she chose to teach types of relative clauses that

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were more difficult than what the students already knew on the hierarchy of difficulty established in prior research. Conditions included form-focused and meaning-focused help.

Hegelheimer, V., & Chapelle, C. A. (2000). Methodological issues in research on learner-computer interactions in CALL. *Language Learning and Technology, 4*(1), 41–59.

This article explores methodological issues pertaining to the use of instructional tasks for gathering data that are used for making inferences about learners' processes. Taking as an example the assessment of "noticing," the authors discussed the assessment issues and options and illustrated how such data can be gathered with an online example that gathers data on noticing, tests retention of word meaning, and calculates the correlation between noticed and remembered words.

Hulstijn, J. H. (2000). The use of computer technology in experimental studies of some techniques and some ongoing studies. *Language Learning & Technology, 3*(2), 32–43.

This article provides an overview of some ways that SLA researchers use the computer to elicit L2 production data or to record how L2 learners process L2 input. Examples are drawn from experiments in psychology as well as some SLA studies on automaticity in reading and writing. It is the article introducing a two-volume special issue of *Language Learning & Technology* on SLA and CALL.

Plass, J. L., Chun, D. M., Mayer, R. E., & Leutner, D. (1998). Supporting visual and verbal learning preferences in a second-language multimedia learning environment. *Journal of Educational Psychology, 90*(1), 25–36.

This article is an excellent of example of how research on learners' use of CALL materials (i.e., second language classroom research) can be framed theoretically and interpreted in terms of implications for materials development. The researchers gathered quantitative data on learners' selection of a variety of vocabulary help, and analyzed relationships between help selection and vocabulary retention.

Warschauer, M. (1999). *Electronic literacies: Language, culture, and power in online education*. Mahwah, NJ: Erlbaum.

Drawing on ethnographic methods to investigate how technology is used in different classrooms, this book shows how language learning technology intersects with broader issue of teachers' beliefs and learners' prior experience. The study investigated culturally and linguistically diverse learners, including immigrants to the United States; Native Hawaiian

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students; and international students from Latin America, Asia, and the Pacific.

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