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Research Timeline

Tutorial computer-assisted language learning

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Introduction

'Sometimes maligned for its allegedly behaviorist connotations but critical for success in many fields from music to sport to mathematics and language learning, PRACTICE is undergoing something of a revival in the applied linguistics literature' (Long & Richards 2007, p. xi). This research timeline provides a systematic overview of the contributions of computer-assisted language learning (CALL) to the role, nature, and development of individual practice in language learning. We focus on written language practice in Tutorial CALL, corrective feedback and language awareness-raising in Intelligent CALL (ICALL), and individualization of the learning process through tailoring of learning sequences and contingent guidance.

The origins of CALL can be traced back to the early 1960s. Early attempts in CALL followed the contemporary concept of Programmed Instruction (PI), proposed by the behaviourist psychologist B. F. Skinner. PI delivers information to be learned in small chunks, is self-paced by the learner, and provides immediate, corrective feedback. Moreover, PI in CALL was largely based on the assumption that students learn the language in the classroom and practise it on the computer. For this reason, computer feedback limited to basic knowledge-of-result (Annett 1969) was deemed sufficient.

Almost all research and development in CALL in the 1960s to 1990s can be labelled Tutorial CALL. Tutorial CALL describes the interaction of language learners WITH the computer in contrast to computer-mediated communication, another yet much larger area of CALL, in which learners, instructors, and speakers of the second language (L2) interact with each other VIA the computer. In Tutorial CALL, the computer is commonly used for sentence-based practice activities in the form of multiple choice or multiple select, fill-in-the-blank, match or rank answers, and reassemble or translate small chunks of text. When it comes to academic enquiry in Tutorial CALL, the rapid pace of technological development from dumb terminals and large mainframe computers to microcomputers and other small devices entailed an iterative re-focus on changing technologies. Although the curricular and pedagogic context of foreign language learning changed comprehensively and rapidly

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through a new focus on different conceptualizations of communicative competence (Hymes 1966; Canale & Swain 1980; Krashen 1982), this is not always evident in the pedagogic design of Tutorial CALL. The same, or very similar, learning activities were rewritten for new computer hardware and operating systems. Their storage capacity and processing speed increased and the user interface, including the handling of diacritics and non-Roman scripts, improved greatly. Just-in-time delivery across vast networks and the addition of genuine multimedia capabilities, such as audio and video clips embedded in activities and spoken learner input for multiple-choice exercises, became possible. The essential language learning activities with simplistic knowledge-of-result feedback, however, remained largely unchanged. The proliferation of multimedia-capable machines after the launch of the Macintosh in 1984 and Microsoft's Windows 3.1 in 1992 contributed to the pedagogic innovation stagnating. Similarly, these learning activities were ported to web servers with the advent of the World Wide Web in 1993 with less sophisticated techniques of input processing and less informative corrective feedback than in comparable stand-alone programs. Activity formats and feedback algorithms remained the same although second language acquisition research and pedagogic practice had moved on. In their communicative classrooms, students were taught less about linguistic structures and were thus often ill-equipped to learn during individual practice with a Tutorial CALL program. It was largely in the field of ICALL that research focused on enriching the learning experience by providing contextual metalinguistic feedback and instructional guidance based on the complex linguistic processing of students' textual input. However, the changing role of language practice in Tutorial CALL, from reinforcing and automatizing language skills learned in the classroom to developing language skills and learning about language structures outside of the communicative classroom, is as yet under-researched.

In early programmed learning approaches in Tutorial CALL, learners were provided with mainly mechanical practice (DeKeyser 2007) of selected grammatical phenomena and lexical items. The programs were limited to simplistic knowledge-of-result feedback generated by monolithic string-matching algorithms and binary holistic answer processing (Right vs. Wrong, Try again) in addition to more sophisticated matching to regular expressions ('Regular expression' 2013). More detailed feedback on error location was achieved by leaving the anticipated character substring of the student answer intact and highlighting or deleting the substring that deviated from the model answer.

Changes that did occur within the research and development efforts of Tutorial CALL focused on the individualization of the learning experience. Tutorial CALL packages paid particular attention to branching, the individualization of practice sequences. Based on calibrated item difficulty—a tenet of classical testing theory, which depends on scores for a completed activity—students would be presented with more difficult practice material after achieving a high score and less difficult and remedial practice material after obtaining a low score. The main challenge for Tutorial CALL activities that rely on more or less sophisticated string-matching algorithms to provide students with contextual corrective feedback and/or additional instructional guidance is that they have to be based on the anticipation of each and every possible correct and erroneous answer in order for them to be robust and comprehensive. Of course, the number of well-formed utterances in a language is infinite and the number of erroneous utterances is then infinitely infinite. In the absence

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of comparing the student's input string to the strings of anticipated answers, the computer needs to be capable of a linguistic analysis of student input to detect errors and to provide corrective feedback and contextual instructional guidance. Broadly speaking, this research approach is taken in ICALL.

ICALL is the label of predominantly Tutorial CALL applications at the nexus of Artificial Intelligence (AI) and CALL. ICALL relies on natural language processing (NLP), student modelling, and expert systems. NLP produces a formal linguistic representation of learners' linguistic input with the goal to provide corrective feedback and instructional guidance. The record of this information over time, which is maintained in student profiles, provides the basis for inferring interrelated facets of the student's cognitive belief system about the learned language, that is, the construction of a student model. Information from the student model, in turn, provides some basis for the tailoring of learning sequences and contingent guidance. Expert systems model the learning domain, such as aspects of the grammar of a language, and are a rich source of structured (linguistic) knowledge that can guide and scaffold the students' learning processes. They enable learners to query this knowledge base during task completion thus serving as a comprehensive reference tool in learner-computer interactions.

Most research in ICALL between 1978 and the early 2000s was aimed at grammar checking for language learners, error detection and correction of learner input, and the provision of more informative, metalinguistic learner feedback. After thorough discussions of the NLP-hard problems of analysing learner language and error classification and their annotation in learner corpora, ICALL research has focused increasingly on the implementation of robust human language technologies such as lemmatizers (i.e., algorithms which aim to remove inflectional endings to return the base form or dictionary entry of a word), part-of-speech taggers, and parsers to analyse well-formed texts and augment them with additional information that is made available and useful to language learners (Schulze & Heift 2013). The information (e.g., conjugational paradigms of verbs in a reading text and/or highlighted less salient word classes such as prepositions) focuses the learners' attention, helps them notice linguistic patterns by raising their language awareness, and/or scaffolds their language use.

Our belief about the pedagogic importance of corrective feedback, instructional guidance, and language awareness-raising in language learning practice and the nature of the developmental trend described above led us to include fewer publications on Tutorial CALL based on simple string-matching algorithms for the analysis of learner language. The literature on these is also scarce. Authoring tools for language learning practice, for example, Camsoft's Fun with Texts (www.camsoftpartners.co.uk/fwt.htm) and the Wida suite of software, as well as general instructional authoring software such as Toolbook (http://tb.sumtotalsystems.com/) or software for designing tests such as the Question Mark products (www.questionmark.com) were very popular among language instructors and were presented and discussed at workshops, but hardly ever featured in research articles. Accordingly, we identified the following themes in the publications provided in our timeline:

- Survey and review articles
  - Overviews (O) summarize the state of the art at that time and focus on research questions or challenges pertinent to Tutorial CALL;

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  - Background articles (B) discuss important processes and variables in Tutorial CALL without necessarily focusing on one particular project.
- Pedagogy articles (P) discuss general aspects of second language development and language teaching methodology. Two important specific aspects are identified:
  - Corrective Feedback (F) subsumes form-focused feedback on individual items of practice activities, written texts and dialogues, and generally the recognition and processing of learner errors;
  - Language Awareness (A)—understood very broadly—encompasses scaffolding resources for students' perceptive activities and guidance that focuses their attention, facilitates noticing, and generally helps learners to sequence the necessary steps in a complex problem-solving process.
- Research and development projects
  - ICALL project (I);
  - Tutorial CALL project—no NLP (T).

References

Annett, J. (1969). *Feedback and human behaviour: The effects of knowledge of results, incentives and reinforcement on learning and performance*. Middlesex: Penguin Books.

Canale, M. & M. Swain (1980). Theoretical bases of communicative approaches to second language teaching and testing. *Applied Linguistics* 1, 1–47.

DeKeyser, R. (ed.) (2007). *Practice in a second language: Perspectives from applied linguistics and cognitive psychology*. Cambridge: Cambridge University Press.

Hymes, D. (1966). Two types of linguistic relativity. In W. Bright (ed.), *Sociolinguistics*. The Hague: Mouton, 114–158.

Krashen, S. (1982). *Principles and practice in second language learning and acquisition*. Oxford: Pergamon.

Long, M. & J. Richards (2007). Series editors preface. In R. DeKeyser (ed.), *Practice in a second language: Perspectives from applied linguistics and cognitive psychology*. Cambridge: Cambridge University Press, xi.

Regular expression. (2013). In *Wikipedia*. Retrieved 12 December 2013, from http://en.wikipedia.org/wiki/Regular_expression.

Schulze, M. & T. Heift (2013). Intelligent CALL. In M. Thomas, H. Reinders & M. Warschauer (eds.), *Contemporary computer-assisted language learning*. London: Bloomsbury, 249–265.

TRUDE HEIFT is Professor of Linguistics in the Department of Linguistics at Simon Fraser University, Canada. Her main research areas focus on the design as well as the evaluation of CALL systems. From an SLA perspective, her work examines learner-computer interactions (e.g. navigation patterns, learner strategies and responses within intelligent systems, learner and task variables), corrective feedback and error analysis by focusing on an interactionist SLA approach in her research projects. From a computational point of view, she is interested in the automatic analysis of learner language and learner modeling. She is currently co-editor of *Language Learning & Technology*.

MATHIAS SCHULZE is Associate Professor of German (Applied Linguistics) at the University of Waterloo in Canada. Together with Bryan Smith, he edits *CALICO Journal*, which publishes research on computer-assisted language learning. His own research focuses on Tutorial CALL, the application of artificial intelligence to CALL, the development of language proficiency, and online language learning. Complex Systems Theory and Activity Theory are the source and basis for his approach in research projects.

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1968	Adams, E., H. Morrison & J. Reddy (1968). Conversations with a computer as a technique of language instruction. *The Modern Language Journal* 52.1, 3–16.	**Adams et al.** describe a new type of language laboratory with individual terminal stations (IBM 7010). The exercises, first implemented for L2 German, serve as vehicles for language practice by rewarding exploratory behaviour and facilitating trial and error learning through iterative improvement. When the student makes an error, the program provides cues to help improve the learner's performance in the form of pattern mark-up, i.e., dashes. The program also keeps a record of student performance to determine whether the student meets the teacher's standards.	T, F
1972	Curtin, C., D. Clayton, C. Finch, D. Moor & L. Woodruff (1972). Teaching the translation of Russian by computer. *The Modern Language Journal* 56.6, 354–360.	**Curtin et al.** discuss a reading course for Russian which is part of the PLATO system developed at the University of Illinois. PLATO consists of student stations with a television screen and a typewriter keyboard and provides individual instruction by presenting learning material to be mastered at the learner's own pace. Remedial sequences are also provided, some optional and some required. Reference material includes explanations of grammar or glossaries (see also Hart 1995).[1]	T, F
1978	Weischedel, R., W. Voge & M. James (1978). An artificial intelligence approach to language instruction. *Artificial Intelligence* 10, 225–240.	**Weischedel et al.** describe the pioneer work in ILTSs with a system for L2 learners of German reading comprehension. Implemented as an Augmented Transition Network (ATN), the system contains buggy rules—rules that describe grammatically ill-formed sentences—to identify certain syntactic mistakes and a semantic analyser that diagnoses several kinds of comprehension problems and semantic errors. Fine distinctions in meaning are represented to detect the misuse of words. ICALL systems that follow differ with regard to their grammatical formalisms, coverage of grammatical phenomena, and target language.	I, F, P
1979	Taylor, H. (1979). DECO/TUCO: Students' reactions to computer assisted instruction in German. *Foreign Language Annals* 12.4, 289–291.	**Taylor** presents DECO (completed in 1973) and TUCO (completed in 1974), two CALL systems for grammar practice for L2 learners of German. Both DECO and TUCO are authored on an IBM mainframe using IBM's Coursewriter 3 authoring system, which uses exact and partial matching for general feedback and additional specific feedback provided by pre-programmed error anticipation. If students make a mistake in the sentence-based exercises, the program offers advice as to the nature of the error and computer responses adapt to the student's response.	T, F

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1982	Sanders, A. & R. Sanders (1982). Spion: 'Intelligent' computer games for German language teaching. In *Proceedings of the Foreign Language Instructional Technology Conference*. Monterey, CA: Goethe Institute and Defense Language Institute, 141–146.	*Spion* is an innovative adventure game for L2 learners of German, initially written in the computer programming language PL/1 and, in 1987, implemented in PROLOG. In the game, the student takes the role of a spy in East Germany, who has to obtain some specified information. *Spion* recognizes a small fragment of German, yet it is large enough to allow a student to play the game. The feedback students receive is often gamified. For example, if students use a word the system does not recognize, they are told it might be a taboo word, which a spy should not use. The authors discuss the history of their artificial intelligence-based spy game in their chapter in HOLLAND, KAPLAN & SAMS (1995). See also Molla, Sanders & Sanders 1988.[2]	I, F, P
1982	Underwood, J. H. (1982). Simulated conversation as a CAI strategy. *Foreign Language Annals* 15.3, 209–212.	**Underwood** describes FAMILIA, an ICALL system for L2 learners of Spanish, which employs simulated conversation strategies that allow students considerably more freedom in their responses. Error-checking routines monitor for syntactic errors.	I, F
1983	Higgins, J. (1983). Can computers teach? *CALICO Journal* 1.2, 4–6.	**Higgins** discusses two mental models of the teacher, magister and pedagogue, and suggests that with conventional drill-and-practice CALL, we may be assigning the wrong role to the computer. Several programs are described to demonstrate what the computer can do in a non-magisterial role.	P, B, T
1983	Markosian, L. & T. Ager (1983). Applications of parsing theory to computer-assisted instruction. *System* 11.1, 65–77.	The authors describe stand-alone CALL courses for Arabic and Armenian at Stanford University, which are implemented in LISP. The parser of the ICALL programs is used both to analyse student input and to generate grammatical pattern drill exercises to be authored by a language instructor. In addition, the parser is applied to modeling the students' understanding of the L2.	I, F
1983	Pusack, J. (1983). Answer-processing and error correction in foreign language CAI. *System* 11.1, 53–64.	**Pusack** presents five categories of answer processing for Tutorial CALL programs: non-evaluation, right-wrong evaluation, pattern mark-up, error anticipation, and parsing. Each strategy is explained in terms of its operation, its advantages and disadvantages, its ease of use for authoring courseware, and its capability to support individualized instruction.	B, F, T

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1987	Rüschoff, B. (1987). The 'intelligence' of intelligently programmed adaptive CALL materials for self-study. In L. Legenhausen & D. Wolff (eds.), *Computer assisted language learning and innovative EFL methodology*. Augsburg: Universität Augsburg, 74–82.	**Rüschoff** emphasizes the importance of adaptivity in CALL materials for individual study. According to him, flexibility and adaptivity can only be achieved with a meaningful error-analysis of learner input, and a learner model which collects information on the learning history and performance of individual students and interprets it intelligently. While the resulting changes in either course or content can be initiated automatically, the importance and possible advantages of giving the learner a measure of control are discussed (see Pusack 1983, who also emphasizes the need for individual instruction in his classification of answer processing).	T, B, P
1987	Underwood, J. H. (1987). Artificial intelligence and CALL. In W. F. Smith (ed.), *Modern media in foreign language education: Theory and implementation*. Lincolnwood, IL: National Textbook Company, 197–225.	**Underwood** discusses the possibilities and limitations of NLP in CALL by providing an overview of current ICALL systems ('Liesl', 'Juegos Communicativos') and major projects (Athena, TALK, Project Alexis, Intelligent Grammar Tutor). While conceding that even the cleverest programs do not approach the understanding of the human speaker in normal language use, Underwood stresses that it is unnecessary for a CALL system to achieve anything approaching full understanding in order to be useful.	I, B, P
1988	Menzel, W. (1988). Error diagnosing and selection in a training system for second language learning. In *Proceedings of the Twelfth International Conference on Computational Linguistics,* Coling-88, Budapest, Hungary, 414–419.	**Menzel** presents a procedure for error diagnosis for intelligent language tutoring systems (ILTSs). Based on a knowledge representation scheme for a certain class of syntactic correction conditions, his system carries out a thorough analysis of possible error hypotheses and their consequences. A comparison with earlier attempts such as Weischedel et al. 1978 shows an improved precision of diagnostic results.	I, F
1989	Cerri, S. (1989). ALICE: Acquisition of linguistic items in the context of examples. *Instructional Science* 18.1, 63–92.	**Cerri** describes ALICE, an interactive ICALL system that detects and corrects mistakes in translation. The system relies on a pragmatic representation of conceptual differences of linguistic terms in several languages and offers diagnostic and remedial strategies for mistakes made by students in translating from or into any of the available languages. ALICE-chan, the Japanese version, is also discussed in the chapter by Levin & Evans in Holland, Kaplan & Sams (1995). Nagata (1993) used ALICE-chan in her doctoral dissertation and, subsequently, to explore the role of ICALL in foreign language learning (see also Nagata 1996).[3]	I, F

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1989	Chapelle, C. & S. Mizuno (1989). Student's strategies with learner-controlled CALL. *CALICO Journal* 7.2, 25–47.	**Chapelle & Mizuno** investigate students' use of five strategies while they work on learner-controlled CALL grammar lessons. Study results indicate that some students indeed use some of the strategies some of the time. However, the findings also confirm that students are often doing something different from what instructors believe they are doing. They do not always use the optimal strategies, thus prompting the need for teachers and researchers alike to observe students' use of CALL.	T, P
1989	Gale, L. (1989). Macario, Montevidisco, and Interactive Digame: Developing interactive video for language instruction. In W. F. Smith (ed.), *Modern technology in foreign language education*. Lincolnwood, IL: National Textbook, 235–248.	**Gale** describes three interactive videodiscs for Spanish (Macario, Montevidisco, Interactive Dígame) developed at Brigham Young University. The narratives designed to permit participatory interaction use a multiple-choice format for input processing. Research studies carried out with the three CALL systems suggest that, while the capabilities of personalized and classroom interactive video are promising, the need for carefully considered instructional design based on sound theory lies at the heart of any instructional paradigm.	I, P
1989	Murray, J., D. Morgenstern & G. Furstenberg (1989). The Athena language learning project: Design issues for the next generation of computer-based language learning tools. In W. F. Smith (ed.), *Modern technology in foreign language education*. Lincolnwood, IL: National Textbook, 97–118.	**Murray et al.** trace the design decisions of the Athena Language Learning Project (ALLP) during its first three years of implementation. At the base of ALLP are the major principles of a communicative approach to language learning by making use of NLP and interactive video. Students are involved in a fictional story, with characters and a plot, and the development of the story hinges upon their actions. In addition to the narrative, the interactive videos contain generic tools that aid linguistic and cultural comprehension (e.g., subtitles, a glossary). 'Le Quartier St. Gervais' and 'À la rencontre de Philippe' are examples of the French videodisc projects of ALLP.	I, P
1990	Burston, J. (1990). Maximizing intelligent use of unintelligent response handling devices. *CALICO Journal* 8.2, 77–90.	**Burston** argues that, despite their inherent limitations, relaxed pattern matching and automatic mark-up algorithms are capable of satisfactorily evaluating students' sentential input if string-matching and annotation are combined under flexible programming control. By allowing the systematic categorization of student input into fundamental reply types as determined by relative degree of matching with canonical forms, they also provide the basis for meaningful feedback in Tutorial CALL.	B, T, F

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1990	Schwind, C. (1990). An intelligent language tutoring system. *International Journal of Man-Machine Studies* 33.5, 557–579.	**Schwind** describes the theoretical background, design, and implementation of an ILTS for L2 learners of German by focusing on the organization and representation of grammatical, semantic, and lexical knowledge. Her research findings indicate that the possibility of asking questions during an exercise session are generally appreciated and used by students working with the ILTS although exercises should be centered on specific grammatical phenomena.	I, F, P
1991	Garrett, N. (1991). Technology in the service of language learning: Trends and issues. *The Modern Language Journal* 75.1, 74–101.	**Garrett** provides an overview of the growing field of CALL. She discusses the technological resources available to support language learning and argues persuasively that CALL is not a teaching method, but rather a medium that can accommodate a variety of methods and be integrated in different curricula. She also provides an argument for second language acquisition (SLA) research being conducted with the computer because computers can gather data during the learning process in addition to making available the final product (see also Garrett 2009).	O, P
1991	Labrie, G. & L. Singh (1991). Parsing, error diagnostics, and instruction in a French tutor. *CALICO Journal* 9.1, 9–25.	**Labrie & Singh** describe *Miniprof*, an ILTS for L2 beginner learners of French. In case of an erroneous response, *Miniprof* engages the student in a Socratic dialogue. The system asks specific questions about the user input, thereby leading the student to identify each mistake and its correction. In the case of an erroneous sentence, *Miniprof,* which uses a Definite Clause Grammar, attempts to parse the largest well-formed fragment and identifies the remainder as the part that contains an error.	I, F
1991	Laurillard, D. (1991). Principles for computer-based software design for language learning. *Computer Assisted Language Learning* 4.3, 141–152.	**Laurillard** deduces a set of design principles for Tutorial CALL software from research in psycholinguistics and SLA: morpho-syntactic rules need to be introduced explicitly; goal orientation needs to be given to focus attention; activities must be sequenced so that only one new linguistic item is embedded in known linguistic items; and feedback must deal explicitly with any misconceptions.	O, T, P

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1991	Levin, L., D. Evans & D. Gates (1991). The ALICE system: A workbench for learning and using language. *CALICO Journal* 9.1, 27–56.	**Levin et al.** present ALICE, a set of tools for building different types of language-independent ICALL programs developed at Carnegie Mellon University. The central components of ALICE consist of a set of NLP tools, a set of online text, video, and audio corpora, and an authoring language that allows teachers to configure the NLP tools and excerpts from the corpora into ICALL programs.	I
1991	Robinson, G. (1991). Effective feedback strategies in CALL: Learning theory and empirical research. In P. Dunkel (ed.), *Computer assisted language learning and testing: Research issues and practice*. Englewood Cliffs, NJ: Newbury House, 155–168.	**Robinson** argues that effective feedback designs depend on the learner's perceptual and behavioural processes. CALL feedback that guides learners to discover correct and incorrect responses themselves is more effective than the immediate disclosure of answers. Selectively combining student control and programmed help facilitates the individual development of internal learner control and mastery.	T, F
1991	Sanders, R. (1991). Error analysis in purely syntactic parsing of free input: The example of German. *CALICO Journal* 9.1, 72–89.	**Sanders** provides a typology for analysing grammatical errors in student-written German compositions and discusses approaches to providing error feedback in a parser-based writing aid. Examples are drawn from the Miami corpus consisting of second-year German language students' compositions and from *Syncheck*, a syntactic parser of German implemented as the basis of a writing aid for language students.	I, F
1992	Bationo, B. D. (1992). The effects of three feedback forms on learning through a computer-based tutorial. *CALICO Journal* 10.1, 45–52.	**Bationo** investigates the effects of three forms of immediate feedback in Tutorial CALL: spoken, written, and written/spoken feedback. Results indicate that the combination of written/spoken feedback is more effective than each feedback format alone for the immediate recall of the learning material. For the retention of the learning material, however, no significant difference between the combined feedback format and any other format was found. This study marks the beginning of research that investigates different aspects of learner feedback.	T, F
1992	Loritz, D. (1992). Generalized transition network parsing for language study: The GPARS system for English, Russian, Japanese, and Chinese. *CALICO Journal* 10.1, 5–22.	**Loritz** presents GPARS, a generalized transition network system with a formalism that allows top-down, bottom-up, depth-first, breadth-first, deterministic, and nondeterministic parsing strategies to be freely intermixed. These strategies enable the system to be used for parsing Chinese, Russian, Japanese, and other languages (see also his chapter on GPARS in Holland, Kaplan & Sams 1995).	I, F

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1993	Nagata, N. (1993). Intelligent computer feedback for second language instruction. *The Modern Language Journal* 77.3, 330–339.	**Nagata** describes a study in which she compared two versions of her software Nihongo-CALI for teaching Japanese particles. Study results indicate that students who were provided with intelligent feedback generated by NLP outperformed the control group who received traditional feedback that did not explain the functions and semantic relations of nominal phrases in the sentence (see also VAN DER LINDEN 1993 for an investigation of the benefits of learner feedback in CALL).	I, P
1993	Van der Linden, E. (1993). Does feedback enhance computer-assisted language learning? *Computers & Education* 21.1, 61–65.	**Van der Linden** investigates the question of whether language learners learn better by programs with corrective feedback. Her study findings indicate that there is no overall successful strategy. While some students make optimal use of the feedback provided, others seem to avoid using it in several ways. See LAURILLARD 1991 on earlier findings with regard to feedback specificity.	P, F, T
1994	Bull, S. (1994). Learning languages: Implications for student modelling in ICALL. *ReCALL* 6.1, 34–39.	**Bull** describes the student model of an ICALL system that considers issues important in the field of SLA and research in collaborative approaches to learning. She addresses common criticisms towards student models such as system overload and the general lack of accuracy and completeness of a student model.	I, P
1994	Hagen, K. (1994). Unification-based parsing applications for intelligent foreign language tutoring systems. *CALICO Journal* 12.2–3, 5–31.	**Hagen** presents *GrammarMaster*, an ILTS for L2 learners of French with a grammar editor that is built on an object oriented, unification-based natural language processor (Head-Driven Phrase Structure Grammar (HPSG), Pollard & Sag 1994).[4] The author focuses on complex grammatical structures that have been a challenge for previous ICALL systems and provides examples of how the software interacts with students.	I, F
1995	Allen, J. R. (1995). The ghost in the machine: Generating error messages in computer assisted language learning programs. *CALICO Journal* 13.2, 87–103.	**Allen** describes the ELSE program with its fuzzy string matching techniques to generate error messages. The techniques recognize several kinds of generic errors and are applicable to a wide range of situations. The error matching rules are part of the general programming code, thus limiting their portability to other programs, platforms, languages, and learning contexts.	I, F

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1995	Brandl, K. (1995). Strong and weak students' preferences for error feedback options and responses. *The Modern Language Journal* 79.2, 194–211.	**Brandl** investigates the influence of level of achievement and task difficulty on college students' preferences for feedback options. Study results indicate that neither achievement nor task difficulty had a significant impact. The study argues that deficiencies in the low-achievement learners' language skills may contribute to lowering their engagement in cognitive and motivational processing (see Bationo 1992).	I, F
1995	DeSmedt, W. (1995). Herr Kommissar: An ICALL conversation simulator for intermediate German. In V. M. Holland, J. D. Kaplan & M. R. Sams (eds.), *Intelligent language tutors: Theory shaping technology.* Mahwah, NJ: Lawrence Erlbaum Associates, 153–174.	In the dialog game *Herr Kommissar*, students assume the role of a visiting police inspector interrogating five suspects. A 'sergeant' corrects orthographic and morpho-syntactic errors in the inspector's questions. *Herr Kommissar* also maintains a model of the dialog and checks for somesemantic errors. **DeSmedt** calls his approach predication-driven parsing, an approach similar to Head-Phrase Structure Grammar (HPSG) (see Hagen 1994 for another implementation of HSPG). The parser grammar, relying on a 2,330-word lexicon, covers many construction types that intermediate L2 learners of German are likely to use (see Sanders & Sanders 1982 for an earlier AI-based game).	I, F, P
1995	Felshin, S. (1995). The Athena Language Learning Project NLP system: A multilingual system for conversation-based learning. In V. M. Holland, J. D. Kaplan & M. R. Sams (eds.), *Intelligent language tutors: Theory shaping technology*. Mahwah, NJ: Lawrence Erlbaum Associates, 257–272.	The Athena Language Learning Project took place at MIT between 1983 and 1994 and explores the use of three technologies in CALL: NLP, interactive video, and speech processing (see also Murray's chapter in Holland, Kaplan & Sams 1995). The work reflects the understanding of language learning as embedded in transcultural spaces (Kramsch, Morgenstern & Murray 1985).[5] The system supports several languages (English, French, German, Russian, and Spanish) and handles both language understanding and generation. It accepts written student input, and recognizes and corrects grammatical and some pragmatic errors by relaxing constraints of the parser grammar. The same parser has also been adapted for the FLUENT-2 project (see Hamburger's chapter in Holland, Kaplan & Sams 1995).	I, P
1995	Holland, M. & J. D. Kaplan (1995). Natural language processing techniques in computer-assisted language learning: Status and instructional issues. *Instructional Science* 23.5-6, 351–380.	**Holland & Kaplan** discuss the role of NLP techniques for language learning. They distinguish between techniques and trends of parsing and semantic analysis, explain design issues and trade-offs, and present limitations and potential contributions of NLP technology to educational theory and practice.	O, I

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1995	Holland, V. M., J. D. Kaplan & M. R. Sams (eds.). *Intelligent language tutors: Theory shaping technology*. Mahwah, NJ: Lawrence Erlbaum Associates.	This edited volume is based on an ICALL workshop in 1993, organized by the US Army Research Institute. Its 20 chapters provide the first comprehensive overview of ICALL research and development in North America. Contributors were asked in particular to discuss how theory—computer science, computational linguistics, SLA, and learning theories—shape the technological design. Many projects and chapters are evidence of the bidirectional influence of technology and theory. The seminal nature of this book is underscored by the fact that many of its chapters are co-referenced in this research timeline.	I, O, P
1997	Bush, M. D. & R. M. Terry (1997). *Technology-enhanced language learning*. Lincolnwood, IL: National Textbook Company. Commissioned by ACTFL.	The nine chapters of this volume explore new CALL technologies by examining pedagogical strategies, issues of teacher education and, more generally, the technology's impact on the four language skills and its potential to learn about the language learning process. The chapters emphasize that although CALL technology can be an effective force for improving foreign language instruction, unless the teaching profession devises a coherent model for implementation, students will continue to miss out on the potential that technology has to offer for addressing language learning problems.	P, O
1998	Menzel, W. & I. Schröder (1998). *Constraint-based diagnosis for intelligent language tutoring systems*. In Proceedings of the IT&KNOWS Conference at IFIP '98 Congress, Wien/Budapest, 484–497.	**Menzel & Schröder** investigate the parallelism between constraint-based modeling and model-based diagnosis by identifying four major sources of ambiguity that need to be considered when using constraint-based modeling. The authors cite examples from language learning to describe options for dealing with situations in which alternative error descriptions are available.	I, B
1998	Nerbonne, J., D. Dokter & P. Smit (1998). Morphological processing and computer-assisted language learning. *Computer-Assisted Language Learning* 11.5, 421–437.	**Nerbonne et al.** present GLOSSER, an ILTS for Dutch learners of French. GLOSSER provides information on approximately 30,000 different lexemes and relies on lemmatization, part-of-speech disambiguation, lexeme indexing, and bilingual text alignment. Students can obtain information on the grammatical meaning of morphology and entries in a bilingual dictionary as well as examples of word use in an online corpus.	I, A
1999	Arneil, S. & M. Holmes (1999). Juggling hot potatoes: Decisions and compromises in creating authoring tools for the web. *ReCALL* 11.2, 12–19.	*Hot Potatoes* is a hugely popular piece of authoring software for language learning activities on the web, with 3,600 content designers registered in 1999. The authors and programmers of the software discuss (technical) design decisions of *Hot Potatoes*.	T, F

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1999	Bickerton, D. (1999). Authoring and the academic linguist: The challenge of multimedia CALL. In K. Cameron (ed.), *Computer-assisted language learning*. Lisse: Swets & Zeitlinger, 183–202.	**Bickerton** discusses a variety of authoring tools for Tutorial CALL, their evaluation and best use, and the implementation of the tutorial materials created for individual use or web delivery. He concludes by listing four areas that warrant further research in Tutorial CALL: Authoring tool–pedagogy correlations, multimodal cognition, learner differences and multimedia CALL, and learner expectations.	T, P
1999	Michaud, L. & K. McCoy (1999). Modeling user language proficiency in a writing tutor for deaf learners of English. In M. B. Olsen (ed.), *Computer mediated language assessment and evaluation in natural language processing*. Proceedings of a symposium sponsored by the Association of Computational Linguistics and International Association of Language Learning Technologies. University of Maryland: Association for Computational Linguistics, 47–54.	**Michaud & McCoy** discuss the user modeling architecture of ICICLE, an ICALL system for deaf learners of written English. The model represents the user's language proficiency at a high level of granularity and specificity and designed to be referenced during both writing analysis and feedback production. For an earlier discussion and implementation of such a student model, see Bull 1994.	I, F, P
1999	Yoshii, R. & A. Milne (1999). DaRT: A CALL system to help students practice and develop reasoning skills in choosing English articles. *CALICO Journal* 16.2, 121–155.	**Yoshii & Milne** present DaRT, a CALL system designed for ESL students to master English articles. DaRT uses a diagrammatic reasoning tool to present communicative contexts for exercises in choosing appropriate articles. The system can generate exercise sentences, provide help based on student interactions, and choose the next exercise based on student performance.	T, A
2001	Heift, T. & D. Nicholson (2001). Web delivery of adaptive and interactive language tutoring. *International Journal of Artificial Intelligence in Education* 12.4, 310–325.	**Heift & Nicholson** discuss *German Tutor*, a web-based ILTS for L2 German. Their approach emphasizes generality and individualization, which is achieved through a dynamic Student Model (see Bull 1994). System performance and efficiency is enhanced using a modular system within a three-tier architecture.	I, F, P

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2001	Pujolà, J.-T. (2001). Did CALL feedback feed back? Researching learners' use of feedback. *ReCALL* 13.1, 79–98.	**Pujolà** explains the design and implementation of the feedback features of the CALL program ImPRESSions and describes a study in which he investigated how learners used these in four different sessions using the CALL program. Learners' screen movements, observation and retrospection questions about the use of help facilities were recorded for later description and analysis. Results about the use of the feedback facility are presented and discussed from a qualitative perspective.	P, F
2001	Salaberry, M. (2001). The use of technology for second language learning and teaching: A retrospective. *The Modern Language Journal* 85.1, 39–56.	**Salaberry** argues that whereas most 'new technologies' (radio, TV, VCR, computers) may have been revolutionary in the overall context of human interaction, it is not clear that they have achieved equal degrees of pedagogical benefit in L2 teaching. He discusses four major issues related to the pedagogical effectiveness of different technologies.	P
2002	Segler, T. M., H. Pain & A. Sorace (2002). Second language vocabulary acquisition and learning strategies in ICALL environments. *Computer Assisted Language Learning* 15.4, 409–422.	The authors investigate the role of vocabulary learning strategies in ICALL environments both in terms of perceived helpfulness and assessed growth of lexical knowledge. Based on existing taxonomies, they present a Vocabulary Learning Strategies (VLS) taxonomy, which is validated by factor analysis and evaluated by experienced language teachers in terms of being able to serve as a basis for providing ICALL teaching materials. The authors also address the question of how to measure and assess lexical knowledge.	I, B
2002	Toole, J. & T. Heift (2002). The Tutor Assistant: An authoring system for a web-based intelligent language tutor. *Computer Assisted Language Learning* 15.4, 373–386.	**Toole & Heift** describe *Tutor Assistant*, an authoring tool for an ILTS for English as a Second Language (ESL), designed to be usable by language instructors with little or no experience of ILTSs and ILTS authoring tools. The authors report on a user study that evaluates the degree to which typical users of *Tutor Assistant* can author good quality content for an ILTS and establishes benchmarks for development times.	I, B
2003	Bangs, P. (2003). Engaging the learner: How to author for best feedback. In U. Felix (ed.), *Language learning online: Towards best practices.* Lisse: Swets & Zeitlinger Publishers, 59–80.	**Bangs** explores the question of why good learner feedback is lacking in so many CALL programs. He suggests there is a gap between language learning pedagogy and the design process. While pedagogical designers need to understand the technical possibilities which they can use to put appropriate learning theories into effective practice, the technology community needs to understand what the language learning community really requires from the application of new technologies. He believes that advances with authoring tools (e.g., his 'MALTED' system) have allowed non-programmers to become more in control of the design process, thus allowing them to integrate powerful feedback processes.	B, F

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2003	L'haire, S. & A. Vandeventer Faltin (2003). Error diagnosis in the FreeText project. In T. Heift & M. Schulze (eds.), special issue on error analysis and error correction in computer-assisted language learning. *CALICO Journal* 20.3, 481–495.	**L'haire & Vandeventer Faltin** present *FreeText*, an automatic error diagnosis system for L2 French learners. They discuss the two main features of FreeText and its collected learner corpus FRIDA: (1) a syntactic checker which makes use of two different diagnosis techniques to detect errors of grammatical nature, and (2) a sentence comparison tool which compares learners' answers with those stored in the system to detect semantic discrepancies.	I, F
2003	Nerbonne, J. (2003). Computer-assisted language learning and natural language processing. In R. Mitkov (ed.), *Handbook of computational linguistics*. Oxford University Press, 670–698.	**Nerbonne** examines the application of NLP to CALL with a focus on current developments and opportunities by including the history of work in this academic field over the past 35 years. He draws attention to the fact that a number of robust human language technologies such as aligned corpora are as yet underutilized in CALL in spite of their suitability for language learning activities.	B, O
2003	Schulze, M. (2003). Grammatical errors and feedback: Some theoretical insights. *CALICO Journal* 20.3, 437–450.	**Schulze** discusses theoretical aspects of learner feedback by presenting theoretical considerations with regard to the dialog that takes place with the learner about linguistic errors. Examples are drawn from insights gained during the work on *Textana*, an ICALL prototype for L2 German learners.	F, P, I
2004	Gamper, J. & J. Knapp (2002). A review of intelligent CALL systems. *Computer Assisted Language Learning* 15.4, 329–342.	**Gamper & Knapp** provide an overview of the most advanced ICALL systems. They classify them along five dimensions (i.e., supported languages, artificial intelligence techniques, language skills, language elements, and availability) and discuss outstanding problems that need further research in order to exploit the full potential of ICALL.	I, O
2004	Heift, T. (2004). Corrective feedback and learner uptake in CALL. *ReCALL* 16.2, 416–431.	**Heift** investigates the effects of corrective feedback on learner uptake in CALL whereby learner uptake is defined as learner responses to corrective feedback in which, in case of an error, students attempt to correct their mistake(s). Her findings indicate that feedback which provides an explanation of the error and also highlights the error in the student input is most effective at eliciting learner uptake. The study extends earlier feedback studies (e.g., ROBINSON 1991; BATIONO 1992; BRANDL 1995; PUJOLÀ 2001) by also considering learners' reactions.	F, P, I

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2004	Hubbard, P. & C. Siskin (2004). Another look at Tutorial CALL. *ReCALL* 16.2, 448–461.	**Hubbard & Siskin** discuss several common myths about Tutorial CALL by offering six reasons as to why Tutorial CALL has been marginalized. There is evidence that, despite the presence of these myths and this marginalization, CALL practitioners around the world continue to find Tutorial CALL appealing for research and development (see also the discussion of the highly popular authoring tool, *Hot Potatoes*, by Arneil & Holmes 1999).	T, P, B
2007	Heift, T. & M. Schulze (2007). *Errors and intelligence in CALL. Parsers and pedagogues*. New York: Routledge.	**Heift & Schulze** provide the first comprehensive overview of theoretical issues, historical developments and current trends in ICALL. The book assumes a basic familiarity with SLA theory and teaching, CALL, and linguistics.	I, O, B, P
2007	Johnson, W. (2007). Serious use of a serious game for language learning. *Frontiers in Artificial Intelligence and Applications* 158, 67.	**Johnson** describes the Tactical Language and Culture Training (TLCT) system, a program designed to help learners acquire basic communicative skills in foreign languages and cultures. Learners acquire communication skills through a combination of interactive lessons and serious games. AI is used to process the learner's speech, to interpret and evaluate learner actions, to control the response of non-player characters, to generate hints, and to assess the trainee's mastery of the skills. AI also assists in the authoring process for the generation and validation of lesson content (see also Johnson et al. 2005).[6]	I, F
2009	Garrett, N. (2009). Computer-assisted language learning trends and issues revisited: Integrating innovation. *The Modern Language Journal* 93, 719–740.	**Garrett** discusses the changes that have taken place over the past two decades including the relationship between pedagogy, theory, and technology, infrastructure, efficacy, copyright, categories of software, and evaluation. She explores new demands in language education, the need to rethink grammar instruction, online learning, social computing, teacher training and professional development, and CALL research by making reference to her 1991 article (see Garrett 1991).	O, P
2009	Otto, S. & J. Pusack (2009). Computer-assisted language learning authoring issues. *The Modern Language Journal* 93, 784–801.	**Otto & Pusack** argue that a shift in CALL authoring away from traditional Tutorial CALL programs has taken place with the evolution of the internet, giving rise to many services and applications that facilitate online communication, collaboration, information sharing, social networking, and virtual simulations (see earlier discussions on authoring tools by Pusack 1983; Bickerton 1999; Bangs 2003).	T, B

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2010	Heift, T. (2010). Developing an intelligent language tutor. *CALICO Journal* 27.3, 443–459.	**Heift** discusses *E-Tutor*, an ICALL system for L2 German learners that has undergone several system updates since its initial implementation in 1999. The article focuses on the pedagogical benefits of ICALL systems by also providing reflections on the development of such systems that resulted from the lessons learned in building and maintaining *E-Tutor* (see HEIFT & NICHOLSON 2001).	I, P
2010	Meurers, D., R. Ziai, L. Amaral, A. Boyd, A. Dimitrov, V. Metcalf & N. Ott (2010). *Enhancing authentic web pages for language learners*. In Proceedings of the 5th Workshop on Innovative Use of NLP for Building Educational Applications, NAACL-HLT 2010. Los Angeles, USA, 10–18.	**Meurers et al.** present WERTi (Working with English Real Texts interactively), an NLP architecture and web-based implementation which provides automatic visual input enhancement for web pages. Learners choose the web pages they want to read and the system displays an enhanced version of the pages by also providing fill-in-the-blank exercises and clickable versions of such pages supporting learner interaction.	I, A
2010	Ott, N. & D. Meurers (2010). Information retrieval for education: Making search engines language aware. In Weir, G. & S. Ishikawa (eds.), *Themes in science and technology education* (vol. 3.1-2). Special issue on computer-aided language analysis, teaching and learning: Approaches, perspectives and applications, 9–30.	**Ott & Meurers** discuss a prototype of a search engine that uses information retrieval technology to allow language teachers to search for texts in terms of their contents, reading difficulty and other language properties. (For a related discussion on visual enhancements and automatic activity generation, see MEURERS ET AL. 2010)	I, A
2010	Otto, S. (2010). Decades of CALL development: A retrospective of the work of James Pusack and Sue Otto. *CALICO Journal* 27.3, 435–442.	In honour and memory of James Pusack, a pioneer developer of CALL materials for German and of software tools to aid other developers, **Otto** provides a retrospective of their collaborative work over the past three decades. In 1976, and still in use today, they developed *Dasher,* which is both an authoring and a delivery system for language practice in the form of an electronic workbook. For teachers, *Dasher* helps them to develop a wide range of exercise types efficiently. For students, *Dasher* helps them to locate mistakes in their answers and correct them without verbose explanations (see ADAMS ET AL. 1968).	O, T, F

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2011	Amaral, L., D. Meurers & R. Ziai (2011). Analyzing learner language: Towards a flexible NLP architecture for intelligent language tutors. *Computer Assisted Language Learning* 24.1, 1–16.	**Amaral et al.** discuss TAGARELA, an ILTS for L2 learners of Portuguese, by investigating the connection between system architecture and activity design for foreign language teaching (FLT). TAGARELA connects the specific needs of activities in FLT to the current development of NLP architectures to address the heterogeneous learner input that results from a wider range of FLT activity types (see also HEIFT 2010 for an ILTS for L2 German learners).	I, F
2011	Blake, R. J. (2011). Current trends in online language learning. *Annual Review of Applied Linguistics* 31, 19–35.	**Blake** traces recent studies of online learning by focusing on its application to language learning through Tutorial CALL, social computing, and games for language learning. He shows that Tutorial CALL and computer-mediated communication, along with the inclusion of language games, can complement each other in the service of modern language instruction.	O, T
2011	Cotos, E. (2010). Potential of automated writing evaluation feedback. *CALICO Journal* 28.2, 420–459.	**Cotos** presents an innovative approach to the development and empirical evaluation of Automated Writing Evaluation (AWE) technology. She introduces IADE (Intelligent Academic Discourse Evaluator), a web-based AWE program that analyses the introduction section of research articles and generates immediate, individualized, discipline-specific feedback. Her study results indicate that color-coded and numerical feedback possesses potential for facilitating language learning, thus extending previous findings on learner feedback (see PUJOLÀ 2001 and HEIFT 2004).	I, F
2011	Wood, P. (2011). Computer assisted reading in German as a foreign language, developing and testing an NLP-based application. *CALICO Journal* 28.3, 662–676.	**Wood** presents *QuickAssist*, an ICALL system for L2 German learners that provides a range of NLP tools with the goal to enable learners to independently read and comprehend an electronic German text of their choice. Learners can access a dictionary, a thesaurus, a concordancer, and a morphological analysis of complex words as well as query the German Wikipedia for additional information.	I, A

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2012	Hahn, M. & D. Meurers (2012). *Evaluating the meaning of answers to reading comprehension questions: A semantics-based approach*. In Proceedings of the 7th Workshop on Innovative Use of NLP for Building Educational Applications (BEA7). Association for Computational Linguistics. Montreal, Canada, 94–103.	**Hahn & Meurers** present *CoSeC-DE*, a system that evaluates the content of answers to reading comprehension questions. The approach is based on the semantic formalism Lexical Resource Semantics (LRS) that combines the capability of representing semantic distinctions with the robustness and modularity needed to represent meaning in real-life applications (see also Ott & Meurers 2010).	I, F
2013	Cornillie, F., R. Lagatie, M. Vandewaetere, G. Clarebout & P, Desmet (2013). Tools that detectives use: In search of learner-related determinants for usage of optional feedback in a written murder mystery. In P. Hubbard, M. Schulze & B. Smith (eds.), *Learner-computer interaction in language education: A Festschrift in honor of Robert Fischer*. San Marcos, TX: CALICO, 22–55.	**Cornillie et al.** investigate individual difference factors as determinants of usage of optional metalinguistic corrective feedback in a task-based Tutorial CALL environment for English grammar practice. Mixed-methods research indicates that usage of optional metalinguistic corrective feedback is associated with prior, explicit L2 knowledge. No relation was found with perceived usefulness and achievement goal orientation. (See Heift 2004 for previous findings on metalinguistic learner feedback).	T, F

Note: Authors' names are shown in small capitals when the study referred to appears in this timeline.

[1]Hart, R. (1995). The Illinois PLATO foreign languages project. *CALICO Journal* 12.4, 15–37.

[2]Molla, S., A. Sanders & R. Sanders (1988). Artificial intelligence in a German adventure game: Spion in PROLOG. *CALICO Journal* 6.1, 9–23.

[3]Nagata, N. (1996). Computer vs. workbook instruction in second language acquisition. *CALICO Journal* 14.1, 53–75.

[4]Pollard, C & I. Sag (1994). *Head-driven phrase structure grammar*. Chicago: University Press.

[5]Kramsch, C., D. Morgenstern & J. H. Murray (1985). An overview of the MIT Athena Language Learning Project. *CALICO Journal* 2.4, 31–34.

[6]Johnson, W., H. Vilhjálmsson & S. Marsella (2005). Serious games for language learning: How much game, how much AI? *AIED* 125, 306–313.