

AI in CALL—Artificially Inflated or Almost Imminent?¹

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Abstract:

The application of techniques from Artificial Intelligence (AI) to CALL has commonly been referred to as Intelligent CALL (ICALL). ICALL is only slightly older than the *CALICO Journal*, and this paper looks back at a quarter century of published research mainly in North America and by North American scholars. This ‘inventory-taking’ will provide a basis for establishing the place, context, and direction of ICALL in the *CALICO Journal*, CALICO organization, and CALL research and development in general. As a point of reference, I will use a list of desiderata for ICALL (Oxford, 1993) from the outside perspective of Second Language Acquisition (SLA).

Keywords:

Artificial Intelligence (AI), Natural Language Processing (NLP), Intelligent Computer-Assisted Language Learning (ICALL), Intelligent Tutoring System (ITS)

Introduction

Artificial Intelligence (AI)—a term coined by John McCarthy in 1956—describes “the

¹ To my knowledge, the first one who played with the abbreviation AI in this way was John Sinclair. He gave a presentation with this title at the conference *NLP in CALL* at UMIST in Manchester (England) in May 1998. I used the same title five years later for a presentation at WorldCALL 2003 in Banff (Canada). Although the titles are identical, the argument presented here differs greatly from Sinclair’s and relies on a much more comprehensive survey of ICALL literature than I had available in 2003.

science and engineering of making intelligent machines.” (“Artificial Intelligence,”). This includes research on robotics, intelligent agents, and computer vision. However, most relevant to CALL is the AI research on natural language processing (NLP), user modeling, expert systems, and intelligent tutoring systems (ITS). Natural language processing deals with both natural language understanding—written or spoken language input is turned into a formal representation which captures phonological/graphological, grammatical, semantic, and pragmatic features of the input—and natural language generation—the reverse process, from a formal representation to natural language output. The next branch of AI relevant to CALL—user modeling—can also be described as a sub-area of human-computer interaction research because it strives to adapt computational systems to their users. Of the different research domains in user modeling, student modeling is, of course, of particular relevance to CALL. A student model ‘observes’ the student’s actions, maintains a data structure with this information, and infers beliefs about the student’s knowledge based on these data. Another set of data structures are expert systems. They capture expert knowledge about a particular domain. Both the student model and the expert model are essential components of ITSs. Such systems are tutors in the context of Levy’s (1997) tutor-tool distinction in CALL. They are used in the teaching of various instructional settings and for various subjects and domains.

It is these areas of AI which are commonly applied in Intelligent CALL (ICALL). In other words, ICALL researchers and developers study, employ, and apply artificial intelligence techniques in the area of CALL.² ICALL is very young as a discipline of academic research even compared to a young field such as CALL. The project by Weischedel, Voge and James (1978) was the first and only one in the seventies. Figure 1 provides an overview of the number of NLP in CALL. Altogether, Schulze and Heift (2007) identified 119 ICALL projects, which were documented in English and German publications between 1978 and 2004.

² For a comprehensive overview see Heift and Schulze (2007).

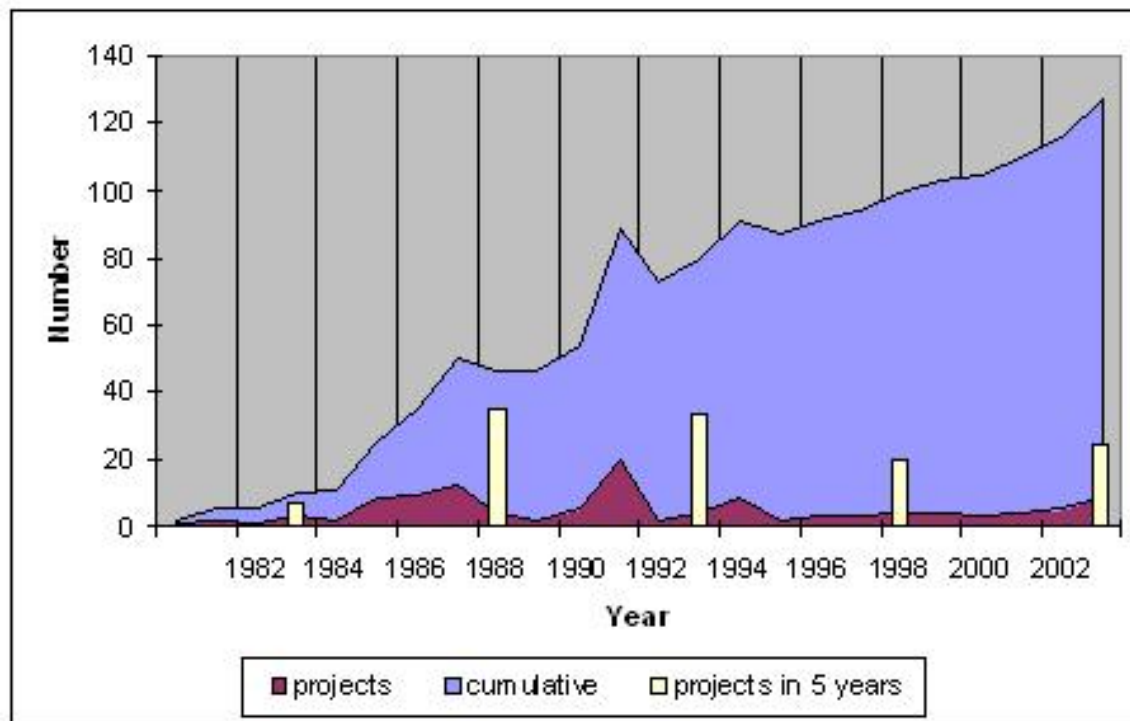


Figure 1: Number of NLP in CALL Projects over Time (Heift & Schulze, 2007, p. 56)

Given the interdisciplinarity of ICALL, it is not surprising that many publications appeared outside the mainstream journals of CALL. This might explain why there is a perception among CALL researchers and developers that the field of NLP in CALL is very small. To give one example: Jung (2002) lists 558 publications in the fifth installment of his indexed CALL bibliography, eleven of these are listed under the keyword *Artificial Intelligence*, seven under *Parser* and only two under *ICALL* because very few articles from the fields of Computational Linguistics, Natural Language Processing, and Artificial Intelligence are actually listed. However, in such comparisons it is the point of reference which matters. If one looks at dedicated journals on CALL, particularly the *CALICO Journal*, *ReCALL*, and *CALL* and considers that there are relatively few researchers in the field of CALL, then it could be argued that these journals contain a comparatively high number of articles on ICALL, an indication that ICALL is a research-intensive area within CALL. On the other hand, if one compares the number of NLP in CALL papers just with the total number of publications in the *ACL Anthology* – A

Digital Archive of Research Papers in Computational Linguistics

(<http://acl ldc.upenn.edu/>), then the number of publications pales in comparison. I will return to this obvious “communication problem and a mutual lack of interest concerning the work done in the neighboring disciplines [CALL and Computational Linguistics].” (Zock, 1996, n. p.) in later parts of this paper.

Here, I would like to continue my evaluation of the situation regarding academic publications on ICALL. The literature on ICALL appeared in a wide variety of different sources. This has already been evident in the two printed ICALL bibliographies (Bailin, 1995; Matthews, 1992), which are by now somewhat dated. A more up-to-date set of bibliographies can be found at the *Integrated Digital Language Learning* website (www.idill.org). There is one monograph (Heift & Schulze, 2007) which provides a comprehensive overview of the work done in ICALL between 1978 and 2005 and an introduction to the main concepts and research questions in the field.. Shorter overviews are found in the chapter by Nerbonne (2003) in the *Oxford Handbook of Computational Linguistics* as well as papers by Matthews (1993) in the *CALICO Journal*, and by Gamper and Knapp (2002). A number of edited volumes contain collections of articles on different projects in ICALL, of particular importance are two books (Holland, Kaplan, & Sams, 1995; Swartz & Yazdani, 1992) which appeared in the United States in the 1990s, because they provide a useful snapshot of important research and development at the time. Other collections of articles appeared in special issues of journals in CALL: in the *CALICO Journal* (Bailin, 1991; Heift & Schulze, 2003b), in *ReCALL* (Schulze, Hamel, & Thompson, 1999), and in *CALL* (Tokuda, Heift, & Chen, 2002); but also in special issues of other journals: *Computers in the Humanities* (Bailin, 1991) and *Journal of Artificial Intelligence in Education* (Chanier, 1994). As is common in Computer Science, collection of refereed papers appeared in proceedings volumes (e.g., Maritxalar, Ezeiza, & Schulze, 2007; Thompson & Zähler, 1992).

The *CALICO Journal*—in the twenty-five years of its existence—has published more than fifty articles that address aspects of research in ICALL. The first appeared in number 2(2) (Hackenberg, 1984) and the last before the time of my writing was Heift (2007). A number of ICALL articles were published together in the two special issues. The first one (Bailin, 1991) was dedicated exclusively to research at the intersection of

Natural Language Processing and CALL—a special issue on ICALL—the second special issue (Heift & Schulze, 2003b) was entitled *Error Analysis and Error Correction*—an research focus which often involves the use of artificial intelligence techniques.

In the following sections, I will draw on selected publications from the *CALICO Journal* and a few other sources predominantly of North American provenance and will use some of these papers to foreground important trends, achievements, and limitations in the ICALL research of the past quarter century. This ‘inventory-taking’ should provide a basis for establishing the place, context, and direction of ICALL in the *CALICO Journal*, *CALICO*, and *CALL* research and development in general. To counter-balance my own in-group view of ICALL, I will introduce an out-group view: Oxford (1993), a researcher in Applied Linguistics and especially in Second Language Acquisition, not necessarily in *CALL*, describes her perception of the situation in ICALL in the mid-nineties as follows:

It was somewhat surprising to me to discover that most of the papers presented at the ARI Workshop contained only outdated language learning and teaching references ... ICALL must devote as much attention to its language learning / teaching principles as it does to its exciting technology (p. 174).

She then continues with nine key desiderata for ICALL:

1. Communicative competence must be the cornerstone of ICALL.
2. ICALL must provide appropriate language assistance tailored to meet student needs.
3. ICALL must offer rich, authentic language input.
4. The ICALL student model must be based in part on a variety of learning styles.
5. ICALL material is most easily learned through associations, which are facilitated by interesting and relevant themes and meaningful language tasks.
6. ICALL tasks must involve interactions of many kinds and these interactions need not be just student-tutor interactions.
7. ICALL must provide useful, appropriate error correction suited to the student’s changing needs.
8. ICALL must involve all relevant language skills and must use each skill to support all

other skills.

9. ICALL must teach students to become increasingly self-directed and self-confident language learners through explicit training in the use of learning strategies. (p. 174)

Oxford is correct in stating that ICALL research has all too often relied on homespun notions of language learning or it borrowed from discourses in Second Language Acquisition (SLA) which had long been criticized severely and/or superseded by theoretical approaches with improved explanatory power. To give just a few examples: Schuster (1986) parsed an English text with Spanish grammar rules if an error was found in order to get a better understanding of transfer errors. However, this project relies exclusively on a contrastive understanding of second language acquisition (Lado, 1957) and thus fails to recognize errors which are due to other interlanguage processes (Selinker, 1974, 1992). Rypa and Feuerman (1995) quote Schuster and also mention contrastive analysis as their main theoretical basis. Others have relied on pedagogical approaches which had been superseded by new language teaching methodologies. Pulman (1984), for example, is rather direct in his rejection of modern communicative and/or cognitive approaches to language learning:

Second language learning, especially during the early stages, is one [activity], where quite a lot of the time what is important is practice and training in correct usage of basic grammatical forms, not the conveying of facts about the world (p. 84).

On the other hand, as can be seen from the discussion below, many researchers in ICALL have shown considerable awareness of current discussion in SLA research and have been successful in implementing relevant research findings in their projects. In my look back on about twenty-five to thirty years of ICALL, I will use Oxford's (1993, p. 174) list of desiderata as points of reference and as my structuring criterion.

Communicative competence must be the cornerstone of ICALL.

The term communicative competence was coined by Dell Hymes to expand on Chomsky's term of linguistic competence, which Hymes found to be too narrow for an

educational context. In addition to a person's ability to know how to construct an utterance grammatically, communicative competence captures this individual's ability to know when, with whom, under what circumstances, and with what purpose to use this utterance. A number of ICALL projects focused on the development of communicative competence of language learners. Jehle (1987), for instance, designed a tool for Spanish (SPANLAB) which resembles the ELIZA program by Weizenbaum. It attempts to engage the learner in a written dialog without correcting any linguistic errors. A similar approach was used by Underwood (1982; 1984, chap. 7), for instance, reports on FAMILIA, a project which heavily borrowed from the ELIZA program by Weizenbaum. In FAMILIA, the system recognizes certain keywords, mainly family terms, and searches for verb complement combinations that are erroneous in Spanish. The entire lexicon as well as the sophisticated pattern matching technique are geared towards this scenario. The communicative approach also played an important role in a very large project, the Athena Language Learning Project. This project was heavily influenced, at least initially, by Claire Kramsch and her ideas about the role of discourse in communicative language learning (Murray, 1991). As a result, aspects such as dialogue and narrative structures were considered. Murray (1991) reports on the problems encountered at MIT when not considering the pragmatic level:

Language teachers are concerned about complex communicative functions such as exchanging greetings, speaking topically, conducting an argument, asking for clarification. Computational linguists, on the other hand, although interested in these larger forms, have done their most concrete work on a tighter level of semantic analysis, such as questions of underspecified referents. Of course these reference ambiguities are basic technical problems that are going to have to be solved if the computer is to become a potent medium for conversational exchanges. But pronoun reference alone does not take us very far toward mimicking human conversation. (p. 7)

However, designing an ICALL system which can be employed in a communicative language learning classroom cannot only be achieved by building a conversational agent. Many ICALL systems in use concentrate more on help with morpho-syntactic errors made by learners, but embed such form-oriented practice activities in a communicative

language course. The *E-Tutor* at Simon Fraser University in Canada (Heift, 1998, 2001, 2002, 2003, 2004; Heift & Nicholson, 2000a, 2000b), for example, is an ICALL system that accepts input from a variety of beginner to intermediate exercises for German and provides error diagnosis and feedback. The system consists of 15 chapters with a variety of learner tasks. It covers the main grammar concepts of German and provides learning content for three semesters of university German. In addition to the grammar and vocabulary tasks, a number of language learning resources, including pictures, audio and cultural information, are contained in the web-based learning environment.

There are also a number systems which set out to diagnose errors in a small, that is, limited domain—examples are introduced in the next section. Some of these systems were used widely, at least for a limited time and usually at the university where they were developed. The research reports indicate that systems with smaller coverage and less ambitious goals are the ones that commonly went beyond a research prototype and were used by language learners. In other words, it was not primarily lack of pedagogic awareness or ambition which led research to conservatively restrict the coverage of an ICALL system, but predominantly considerations of computational feasibility and effectiveness determined the small domain for some projects. Larger, more ambitious projects yielded interesting results from a research point of view, but many were never used in the language classroom. For example, the *Textana* system—a grammar checker for students of German—explored the use of relaxed constraints for feedback generation (Schulze, 1998, 1999, 2001, 2003; Schulze & Hamel, 1998) and attempted a larger coverage of the grammar by accepting all the inherent problems and difficulties. It revealed a number of interesting points on feedback and German grammar from a computational perspective, but was never used by students. This and some other more ambitious projects were conceptualized and designed as language learning tools, not as tutors, and were thus designed to facilitate communicative activities and tasks, often to support form-focused instruction (Lyster, 2007) in a meaningful communicative event.

Of course, ICALL cannot afford to ignore current discourses in SLA (cf. Schulze, forthc.), but always also needs to consider issues related to the computational implementation of SLA theories and approaches in language pedagogy. This makes it more important for ICALL researchers to foster links with researchers in SLA and NLP,

and such links can only be established after fruitful discussions in which researchers from both communities participate. Recent successful examples of creating a platform for such interdisciplinary and multidisciplinary discussions were the two *Interfaces of Intelligent CALL* conferences in Columbus (Ohio) and Waterloo (Ontario) (see <http://www.ling.ohio-state.edu/icall/iicall> and <http://purl.org/i-call>). Equally important is the continued decentralized focus by different researchers on both more applied and more theoretical projects and research questions. The convergence of successful small-scale ICALL research projects and ambitious, theoretical research programs has the greatest likelihood of eventual success.

ICALL must provide appropriate language assistance tailored to meet student needs.

Let us return to examples of small-scale projects. Many ICALL developments of the past focused on one or more specific grammatical phenomena. Bailin (1990), for example, in his *VERBCON* project concentrates only on analyzing verbs that students have to insert into blanks. The centre of attention for Zock and his colleagues (Zock, 1988; Zock, Sabah, & Alviset, 1986) were French clitics. In his *SWIM* project (See What I Mean) (Zock, 1992), students choose certain concepts and ideas and answer questions posed by the system. Depending on their answers, the system generates the French sentence with the appropriate clitics. Yamura-Takei et al. (Fujiwara & Yamura-Takei, 2002; Yamura-Takei, Fujiwara, Yoshie, & Aizawa, 2002) focus on zero pronouns in Japanese in their exercises, and the *TDTDT* project (Pijls, Daelemans, & Kempen, 1987) checks the conjugation of Dutch verbs for morphotactic errors. The *ALICE* system, to add one last example, specializes the analysis of temporal conjunctions in Italian, French and English (Cerri, 1989).

Even on the basis of these few examples, the question, of course, arises: Is the selection of a few (often grammatical) phenomena ‘appropriate language assistance’? If the capabilities and limitations of the ICALL system are clearly communicated to the student, corrective feedback or instructional help on very specific grammatical phenomena such as clitics and verb inflections can be very effective. The appropriateness of such help can

only be determined if one has information about the particular learning environment and communicative learning task, of which the checking or practice activity is only one small part.

Other systems, such as the *E-Tutor* mentioned above, provide language assistance as part of a whole course that was written for the computer. Nagata (1992, 1993, 1995, 1996, 1997, 1998a, 1998b, 2002; 1995), for example, works with a system for Japanese which analyses student input for selected exercises, performs an itemization (separating tokens for later linguistic analysis), performs a morphological analysis and parses the sentential input syntactically using a context free grammar. Such systems with larger coverage and sufficient instructional material are very costly in terms of time and effort. The re-use of computational resources becomes, thus, a necessity. Nagata (1992) as well as Levin and colleagues (Levin & Evans, 1995; Levin, Evans, & Gates, 1991) used the Tomita parser and a morphological analyzer developed by Hausser. The Tomita parser was also employed by Emirkanian and Bouchard (1988a, 1988b). A number of other projects used parsers and grammars that had been developed for different purposes and with different goals in mind, e.g., machine translation. Anderson (1995) evaluates a machine translation system, *Targumatik*, regarding its usefulness for teaching Hebrew and concludes “that MT [machine translation] with a properly constructed and applied learning algorithm can definitely be used to enhance language learning” (p. 90). A different approach to re-use is that the grammar of an existing parser is adapted to another language or to a different application domain altogether. For example, Schulze (1998, 1999, 2001, 2003) modified a parser with a grammar for English (developed by Ramsay) and designed a grammar for German. The same parser was used for the analysis of sentences produced by Japanese learners of English (Brocklebank, 1998). Later, Ramsay’s parser was also used for basic French (Lusuardi, 2005).

Given the huge development times and the considerable expertise needed, the re-use of suitable parsing technology gave these projects a significant advantage. Interestingly, it is very rare that technology or algorithms are borrowed from one ICALL project and re-used in another. The only example—apart from Hamburger’s re-use of the parser originally developed for the ATHENA project—is Lawler (1990, 1993) who ported LINGER (Yazdani, 1991; Yazdani & Uren, 1988) to the Macintosh. It was originally

written for the PC with about 74 context-free grammar re-write rules and a dictionary of about 50 to 70 words per language. Even after extending the dictionary by a factor of 20 Lawler maintains that “the LINGER system ... is not usable in the classroom today” (Lawler, 1990, p. 49). One would wish that the not too distant future will see more fruitful re-use across successful ICALL projects.

When it comes to ‘appropriate language assistance, error detection and diagnosis resulting in corrective feedback has been the main focus of ICALL and thus forms the backbone of the language assistance which is provided by such systems. A larger coverage and hence one aspect of the improved appropriateness of this assistance can be reached through the exploitation of computational linguistics resources and the re-use of technological components and algorithms from other projects. However, language assistance is, of course, not limited to corrective error feedback. ICALL has made great strides toward the successful integration of language engineering resources in CALL. In a number of systems, students have contextualized access to online dictionaries, inflectional paradigms of words are generated on the fly and can be displayed for the student (see e.g., the Glosser-RuG project in Dokter & Nerbonne, 1998; Dokter, Nerbonne, Schürcks-Grozeva, & Smit, 1998; Nerbonne & Dokter, 1999; Roosmaa & Prószéky, 1998). In addition to using language technology to augment language learning materials with additional lexical and morpho-syntactic information the student can access, similar techniques from artificial intelligence can be used to make linguistic features of a text more salient (see e.g., the work on language awareness in Amaral, Metcalf, & Meurers, 2006). It is particularly the latter two areas—providing additional linguistic information and making linguistic features more salient in text—which will have to be explored better by ICALL researchers for two reasons. First, SLA concepts such as scaffolding—the provision of assistance which enables learners to reach communicative goals they would have not reached otherwise—and input enhancement—often extra-linguistic features that enable the learner to comprehend the input better—were shown to have a positive influence on language acquisition success. Both scaffolding and input enhancement correspond well to the provision of additional linguistic help through online dictionaries and to the raising of awareness of selected structural features words, phrases and sentences in the text, respectively. Second, both

processes are normally carried out with linguistically well-formed texts as (computational) input for the NLP analysis. If tools like the lexical look-up, the morphological analyzer, or the syntactic parser do not have to allow for erroneous input, the analysis becomes more robust and hence yields more consistent, reliable results. In other words, sound approaches to SLA and computational effectiveness can be achieved at the same time.

ICALL must offer rich, authentic language input. / ICALL material is most easily learned through associations, which are facilitated by interesting and relevant themes and meaningful language tasks. / ICALL must involve all relevant language skills and must use each skill to support all other skills.

ICALL systems achieved and achieve the provision of rich (comprehensible) input (Krashen, 1982) in three different ways:

- by expanding the coverage of the employed language technology by implementing large computational dictionaries and grammars (e.g., Chen & Xu, 1990; Heidorn, Jensen, Miller, Byrd, & Chodorow, 1982; Richardson & Braden-Harder, 1988);
- by concentrating on selected aspects of NLP and on specific linguistic phenomena (as discussed above) and presenting them in larger authentic texts and tasks;
- by embedding the NLP technology in a language game, virtual world, or simulation as in the following examples.

Spion (Molla, Sanders, & Sanders, 1988; A. F. Sanders & Sanders, 1982; R. H. Sanders, 1995), for instance, which was based on a program without NLP (R. H. Sanders, 1984), was a spy game for students of German. Its main character, Robotky, is placed in Berlin and students have to give him advice in a variety of situations. If students respond in a complete and well-formed sentence, the recommended action will be performed by the screen character. In this system, it is quite interesting to see how the researchers circumvented the problem of a limited parser dictionary. If the system does not recognize a word, it stays 'in character' and tells the student that such a word should not be used in the spy milieu or genre. *Spion* offered the students a motivating, meaningful language

learning task in system which used familiar traits from computer games of the time. Another project, *Herr Kommissar* (DeSmedt, 1995), also relies on a crime story scenario to engage students of German in a written exchange and uses NLP. Students assume the role of the detective (Herr Kommissar) and formulate questions for the suspect during an interrogation. The limited domain and the finite set of syntactic structures for questions results in adequate linguistic coverage for this engaging language game. A very different scenario has been used in a series of projects: American soldiers learning a foreign language are provided with a military scenario in *Bridge* and *MILT* (Jonathan D. Kaplan & Holland, 1995; Jonathan D Kaplan, Sabol, Wisher, & Seidel, 1998; Sams, 1995). Other input and output scenarios are a little more limited, but cover a relevant domain for, in this case beginning, learners. *FLUENT I* (Hamburger & Hashim, 1992) asks students to move objects in a bathroom per request. Hamburger and his team also developed an interface for teachers to create exercises that utilize the natural language processing tools of *FLUENT-2*, both written and spoken. The teacher can use the tutorial schema tool to design interactive exercises, the language tool to influence the language generated by *FLUENT-2* and the drawing tool to manipulate the graphical microworlds (Schoelles & Hamburger, 1996).

Embedding NLP technology in CALL environments which provide a whole task scenario meant that these systems were able to provide students with a stimulating language learning task and at the same time it meant for developers to constrain the linguistic search space for the NLP components. Although the input can be described as rich in the relevant scenario, it usually meant that the system could function adequately although it was based on a small (but contextually relevant) dictionary and a fragment of the L2 grammar.

The ICALL student model must be based in part on a variety of learning styles.

Although student modeling is an important aspect of intelligent tutoring systems, it has not been a strong focus of ICALL (Heift & Schulze, 2007, pp. 171-211). According to Holland and Kaplan (1995) there are two trends in student modeling for language learning: The North American focus lies on the NLP module, the domain knowledge.

Due to the complexity of the NLP component, these systems implement student models only to the extent of analyzing surface errors. In contrast, European systems concentrate on more sophisticated student models by hypothesizing causes of errors (see Chanier, Pengelly, Twidale, & Self, 1992). However, they “opt for narrow NLP bandwidth” (Holland & Kaplan, 1995, p. 364). Susan Bull’s work and that of her collaborators would fit Holland and Kaplan’s impression of student modeling research in Europe. Her student models (Bull, 1993, 1994a, 1994b, 1997a, 1997b, 2000a, 2000b; Bull, Brna, & Pain, 1995; Bull, Pain, & Brna, 1993; Mabbott & Bull, 2004; McCalla, Vassileva, Greer, & Bull, 2000) make explicit reference to a number of variables in individual differences and use elicited information on learning strategies (O’Malley & Chamot, 1990) in collaborative and open learner models based on a small-scale analysis of the linguistic student input (e.g., the analysis of Portuguese clitics). It is, of course, difficult to infer the students’ learning strategies from an observation of their behavior in language learning activities. A number of student models in ICALL, therefore, rely on information which is easier to track. Heift (Heift & Schulze, 2003a) mainly bases her information about individual students on grammatical proficiency measures and increments or decrements the score for a particular grammar constraint evaluating the individual student’s performance. Often the model is based to some extent on error anticipation. Mal-rules capture errors the student made and enable the system to keep track of them in a model. In a system for the teaching of Dutch spelling, the student is modeled with the help of mal-rules for orthographical and the unification aspects of the subject-verb agreement. The system teaches morphotactics (the different realization of morphemes according to their neighboring morphs), verb conjugation and subject-verb agreement (Kempen, 1992; Pijls et al., 1987).

If one considers these approaches to student modeling in CALL in the context of recent discussions in SLA (de Bot, Lowie, & Verspoor, 2005, 2007; Ellis & Larsen-Freeman, 2006; Larsen-Freeman, 1997, 2000, 2003, 2006), then it becomes apparent that a more complex, dynamic model of the learner (Schulze, *forthc.*) needs to be created and maintained in order to adapt the learning environment with its feedback, instructional messages and content to the changing needs of the students.

ICALL tasks must involve interactions of many kinds and these interactions need not be just student-tutor interactions. / ICALL must teach students to become increasingly self-directed and self-confident language learners through explicit training in the use of learning strategies.

The examples mentioned above have already illustrated the fact that ICALL systems—in addition to the tutoring traditionally associated with ITSs—offer a wide variety of interactions. The non-tutorial interactions fall into two broad categories: dialogue systems in which the computer ‘plays the role’ of the conversation partner (Jehle, 1987; Underwood, 1982) and language tools—such as grammar and spell checkers, morphological analyzers, corpus look-up tools—which can be employed in many different interactional settings. A few projects have targeted interactions which can not be classified either as tools or dialogue systems. An interesting pedagogic approach is utilized in CALEB (Cunningham, Iberall, & Woolf, 1987), the Silent Way. The project’s name is even derived from Caleb Gattegno, the developer of the Silent Way. This approach to teaching requires the teacher to provide minimal input and, through trial and error, students *invent* new rules and receive highlighting feedback on errors.

If one interprets Oxford’s term ‘interaction’ not only in the context of SLA, but also in terms of human computer interaction, then it becomes obvious that ICALL systems provide many different types of student input from fill-in-the-blank through sentential input to the handling of large texts. Computer reactions to this input also vary from system to system: Error detection and feedback are very common. Language generation systems (Bailin & Thomson, 1988; Zock, 1992; Zock et al., 1986) provide students with well-formed examples of L2. Systems which augment texts with linguistic information, e.g. by displaying the form paradigm of a verb in the text, react with contextualized help and additional information to a student’s request. Grammar, style and spelling checkers provide guidance during form-focused learning activities and phases. ICALL systems have engaged or at least have the potential to engage language learners in a wide selection of interactions.

ICALL must provide useful, appropriate error correction suited to the student’s

changing needs.

How can the appropriateness of error correction be measured reliably? A number of projects started with a learner corpus to construct a grammar although the size of the corpus used varies vastly. For example, only 48 Japanese sentences were analyzed for a system by Kang & Maciejewski (2000). The system was intended to aid the reading of technical Japanese although the exercises consisted merely of sentence translation. When run on its test-bed essay, *LICE* parsed 30 out of 35 sentences successfully (Bowerman, 1993, p. 198). At the other end of the spectrum, 2254 sentences from 411 business letters were parsed for a benchmark test of *EPISTLE* (Heidorn et al., 1982; Jensen, Heidorn, Miller, & Ravin, 1984) and 64% of them parsed successfully (Heidorn et al., 1982, p. 318). Such studies, of course, only determined whether or not an error could be detected and classified, they did not test whether or not individual students requested corrective feedback and/or benefited from it. Heift (2001, 2002, 2004) has shown that different students react differently to different kinds of feedback. Studies on the reliability of error correction and feedback, on its effectiveness in the learning process, as well as the introduction of evaluation standards for the NLP quality of ICALL systems have become most important if ICALL wants to sustain its development.³

Conclusion

ICALL projects have been documented for a period of thirty years. In its twenty-five years, the *CALICO Journal* has seen a large number of stimulating research essays, project discussions, and empirical studies in ICALL. In this time period, Oxford's (1993) desiderata for ICALL from an SLA perspective have been met by some ICALL projects to some extent. A lot is still waiting to be attempted, implemented, tested and evaluated. With the increased international interconnectivity through the internet, the concentration

³ See for example the workshop by the CALICO Special Interest Group in ICALL "Automatic Analysis of Learner Language: Bridging Foreign Language Teaching Needs and NLP Possibilities" in San Francisco, 2008 (<https://calico.org/p-364-CALICO 08 Workshop.html>).

of language instructors on web-based resources and computer-mediated communication, ICALL has become a major impetus for tutorial CALL (Hubbard & Bradin-Siskin, 2004)—computer-assisted language learning in a structured, operationalized instructional environment. Continued progress in meeting the desiderata discussed here and other related goals can only be made

- if venues for the sustained discussion of research and development issues relevant to ICALL are created. Pre-conference workshops such as the ones organized by the special interest groups in ICALL in CALICO and in NLP in Eurocall or in conjunction with conferences such as Recent Advances in NLP and Coling are important to facilitate discussion and bring different researchers together.
- if the “communication problem and a mutual lack of interest” (Zock, 1996) between researchers in CALL and SLA on one side and Computational Linguistics / NLP on the other are superseded by joint discussions and projects such as the recent Interfaces of ICALL conferences and conferences and publications such as Holland et al. (1995). A turn toward more applied research questions in computational linguistics (ten Hacken, 2003) and a sustained interest in CALL in both modern language technology and tutorial CALL are good reasons to be optimistic.
- if the different aspects of quality of ICALL systems can be measured against established and widely accepted standards. More empirical studies such as the ones by Heift (2001, 2002, 2003, 2004, 2006; Heift & Nicholson, 2000a) which evaluate the effectiveness of ICALL systems, provide insight into SLA processes and outcomes, and inform software design decisions are needed. Aspects such as grammatical and lexical coverage and error detection rate of ICALL systems need to be documented better so that gold standards for these aspects can be developed. Studies such as the ones by Nagata (1992, 1996, 1998a, 1998b), which measure learning outcomes after learners have used ICALL systems are needed. These need to take into consideration the entire bandwidth of language learning activities supported by ICALL systems.

These three broad goals appear to be achievable given that there are discussion venues such as the CALICO Journal which has consistently facilitated the dissemination or

research in ICALL in the twenty-five years since its inception and, I am sure, will continue to do so in the many years to come.

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