Exploring the interdisciplinary synergy between sociocultural theory and intelligent computer-assisted language learning

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1. INTRODUCTION

This chapter explores the potential interdisciplinary synergy between Vygotskian sociocultural theory (SCT) and intelligent computer-assisted language learning (ICALL) in second language (L2) development. A central precept of SCT is that the human mind is mediated by culturally constructed artifacts, understood to include both material and symbolic tools or signs. Through appropriation and intentional use of such resources, human beings come to mediate, or regulate, their relations to others and to the world; this includes changing how they think about and act in the world (Lantolf & Thorne, 2006). A construct in SCT that has proved particularly relevant to understanding L2 development is the Zone of Proximal Development (ZPD). Vygotsky (1978) defines ZPD as the difference between a learner's independent performance and his or her performance when it is externally mediated, typically through interaction with others, including experts and more capable peers. In order to document this developmental change from other-regulation to self-regulation, Vygotsky (1997) proposed an analytical approach known as the genetic method of research. Of particular interest to the present study is microgenetic analysis, which focuses on developmental processes that emerge, or as Vygotsky frequently stated, 'ripen', in a relatively short period of time, such as during the course of an interaction (Wertsch, 1985).

In the L2 acquisition literature, microgenetic development has primarily been studied in the context of moment-to-moment interaction between learners and mediators (e.g., Aljaafreh & Lantolf, 1994). For instance, Ohta (2000) showed how two university-level L2 Japanese learners used verbal cues to provide and respond to developmentally appropriate assistance that facilitated learning and internalization of the Japanese desiderative construction in a translation task over a period of four weeks. The transformation of learners' abilities in the ZPD through dialogic collaboration between learners and expert mediators has been a major focus of L2 researchers working within the framework of Dynamic Assessment (Lantolf & Poehner, 2004; Poehner, 2008, 2011). Through providing appropriate mediation both to understand and to intervene in development, Dynamic Assessment dialogically links assessment and instruction as a single activity (Lantolf & Poehner, 2011; Poehner, 2008).

Recently, scholars have also begun to explore L2 microgenetic development through computer-mediated communication. A project undertaken by Lantolf and colleagues brought these two strands of research together to devise a Computerized Dynamic Assessment (C-DA) approach to diagnosing and supporting learner abilities that employed a web-based system to mediate L2 learners' engagement in listening and reading comprehension tasks in Chinese, French and Russian (Poehner & Lantolf, 2013; Poehner, Zhang, & Lu, 2015). Using a multiple-choice question format, their system traces the number of test questions a learner answered correctly and the number answered incorrectly on the first try while also documenting how much support (i.e., the number of hints or clues) a learner needed in order to complete each assessment task. The C-DA system represents one of the first attempts in exploring L2 microgenetic development in a computerized environment, and has primarily focused on language recognition and comprehension. In this chapter, we explore the synergy between SCT and ICALL with a focus on language production. In what follows, we first provide a historical account of ICALL systems and their potentials to be integrated with SCT principles in order to gain insights for L2 microgenetic development. We then outline some of the unique challenges in ICALL system design. Next, we then present an illustrative ICALL study that provide graduated feedback to L2 Chinese

learners using a language production task. This chapter concludes with recommendations for practice and directions for future studies.

2. HISTORICAL PERSPECTIVES

Driving by the rapid advancement in computational linguistics, particularly natural language processing (NLP, e.g., lemmatization, part-of-speech annotation, syntactic parsing, semantic analysis), and evolving theoretical understanding of second language acquisition, ICALL systems have been designed to automatically enhance textual input, analyze a learner's language production, and provide immediate and individualized feedback to facilitate L2 learning (Amaral & Meurers, 2011; Dickinson, Eom, Kang, Lee, & Sachs, 2008; Heift, 2002, 2004, 2010a; Heift & Schulze, 2007; Lu, forthcoming; Meurers, 2012; Schulze, 2008; Ziegler et al., 2017). Over the past several decades, a number of ICALL systems have been created to support L2 learning in various languages, including German (E-Tutor), Spanish (TAGARELA), Japanese (Robo-Sensei), among others.

Although few ICALL systems have directly drawn on Vygotskian sociocultural theory as a lens to understanding SLA processes, there are potentials to organize Vygotskian pedagogical interventions through an ICALL environment. One such area to explore the SCT-ICALL synergy is individualized or tailored feedback. For instance, E-Tutor provides individualized interactions between the learner and the computer system by emulating a learner–teacher interaction (Heift, 2010a, 2010b). Through the use of an error-checking system, E-Tutor provides feedback to the learner one error at a time. Heift (2010b) reported that L2 German learners showed significant uptake for error-specific feedback over generic feedback type. The nature of the graduated mediation provided by ICALL system created opportunities for the participants to utilize their own mental resources to retrieve the appropriate linguistic forms and take on as much responsibility for task completion as possible.

Another area to explore this synergy is ICALL's ability in tracking user's interaction with the system and document learners' microgenetic development. Based on a customized version of WERTi, Ziegler et al. (2017) examined the extent to which automatic input enhancement of authentic language learning materials can promote L2 development of implicit and explicit knowledge of English articles. By examining how incremental changes in L2 development occur during computerized pedagogical treatment, Ziegler and colleagues showed that the ICALL system WERTi provided the researchers a means to gain insights into the processes and products of L2 development. They noted that ICALL system's impact lies in its abilities to (i) provide feedback automatically (with color coding), (ii) automatically track individual learner's actions and engagement with the system, making it possible to obtain detailed logs of learning process, and (iii) provide a more fine-grained incremental assessment of learner development during treatment (i.e., different activities like Click, Color, Multiple Choice, and Fill-in-Blanks). Similarly, Cowan, Choo & Lee (2014) reported on an ICALL study that integrated explicit concept instruction (e.g., English passives) into an assessment (e.g., editing grammatical errors) that iteratively provide metalinguistic corrective feedback to help L2 learners improve their abilities to recognize and correct persistent grammatical errors in L2 writing.

In addition, scholars have worked to integrate principles from DA, particularly interventionist DA (Lantolf and Poehner, 2004) into ICALL programs. The C-DA project mentioned earlier represents one of the first attempts in bringing Vygotskian pedagogical interventions into the computerized environment. The notion of "intelligence" in ICALL has traditionally been associated with artificial intelligence in computational linguistics, particularly NLP techniques. Ai (2017) suggested to broaden it beyond its technological confine, and focus more on the side of language development. For instance, computer systems that are designed to be sensitive to the extent and type of mediation learners need can also be interpreted as "intelligent", regardless of whether or not the system used NLP software. This is not to say that NLP software is unimportant, but rather the focus should be the creation of an ICALL system that draws upon DA principles (Poehner, 2007), and that is capable of providing immediate, meaningful, and graduated mediation facilitative to second language development.

3. CRITICAL ISSUES AND TOPICS

Research on the SCT-ICALL link has encountered some unique challenges. Related to SCT and DA, one of the critical challenges lies in the quality of the mediation provided by the ICALL system. As Amaral and Meurers (2011) observed, a human teacher is able to consider a wide range of information related to the learner (e.g., proficiency level, age, L1), the task (e.g., type of activity, time available), and the language (e.g., grammatical competence, nature and type of deviations in ill-formed utterances). By contrast, feedback provided by ICALL system tends to be focused only on the language (i.e., grammatical competence).

Another challenge lies in the difficulties in predicting both correct or incorrect answers that are likely to be produced by language learners, particularly open-ended language-related questions. This is because ill-formed input provided by learners affects accuracy for NLP processing (e.g., syntactic parsing), which in turn affects the reliability of the mediation provided by the ICALL system. Nagata (2009) showed that in order to provide a direct response to a simple question, one could obtain 6,048 correct sentences by considering possible well-formed lexical, orthographical, and word-order variants. However, that number jumps to a staggering one million if incorrect options restricted only to incorrect particles and conjugation choices were to be included. This led Heift (2010a) to assert that "it is simply not feasible to anticipate every mistake a student might make" (p. 445). In order for an ICALL system to process learner input effectively and efficiently, Amaral and Meurers (2011) suggested to constraint learners' input in some way (e.g., using the multiple-choice format). Meurers (2012) also pointed out that it might be necessary to "abstract away from the specific string entered by the learner to more general classes of properties by automatically analyzing the learner input using NLP algorithms and resources" (p. 4194).

4. CURRENT CONTRIBUTIONS AND RESEARCH

To illustrate the potential for interdisciplinary synergy between ICALL and SCT, we turn now to a recent research project in which an ICALL instructional enrichment program was designed and employed with L2 learners of Chinese following principles of SCT (Ai, 2015). We focus specifically on the use of graduated approach to feedback (Aljaafreh & Lantolf, 1994) within the ICALL environment in order to mediate L2 microgenetic development. Before providing details of the ICALL system that was used, we offer explanation of the *ba*-construction for readers unfamiliar with this feature of Chinese.

4.1 The Chinese ba-construction

The *ba*-construction is a unique grammatical structure in Mandarin Chinese. Its basic syntactic structure can be schematized as "Subj. + *ba* + NP + VP." In (1), the direct object 这块肉 'this piece of meat' is placed before the verb phrase 拿走 'take away'. This word order differs from the canonical word order in Chinese, which is generally agreed to be Subject + Verb + Object (SVO). The word *ba* was originally used as a verb meaning "to hold/to take" in Middle Chinese and has grammaticalized as a proposition-like element in Modern Chinese (Sun, 2006).

(1) *kuai*　　　*yidian*　*ba*　　　*zhe kuai*　*rou*　　*nazou*
　　快　　　　一点　　把　　　这块　　肉　　　拿走
　　Fast　　　a:little　　BA　　　this-piece　meat　　take-go
　　"Take this piece of meat away quickly!"
　　(Li & Thompson, 1981, p. 463)

Chinese grammarians have suggested that the *ba*-construction has two constraints (Li & Thompson, 1981). The first constraint is that the fronted object or the *ba*-NP must refer to something specific (e.g.,

yige pengyou 'a (particular) friend'), definite (e.g., *na ben shu* 'that book'), or generic (e.g., *qian* 'money'). This is because it does not make sense to talk about a vivid verbal action and its associated results to an entity that has not been established in prior discourse. The other constraint is related to the predicate and stipulates that there must be an element other than the bare verb. The exact reason for the need to have an additional element in the *ba*-construction and the functional purpose of this grammatical construction itself have been a subject of debate among Chinese linguists for more than six decades. A detailed discussion of this on-going debate is beyond the scope of this paper. Interested readers are referred to work by Liu (1997), Jing-Schmidt (2005), and Hsueh (1987).

4.2 Designing an ICALL System for L2 Chinese

The SCT-informed ICALL system is designed to provide graduated mediation to the participants whereby the mediation progresses from implicit and general to explicit and specific and is contingent upon the learner's response to mediation. Unless learners answer the question correctly during their first attempts, the ICALL system always provide the most implicit mediation, which simply reminds them to check their own answer again: "Hmm, can you take a look at it again?" If they still couldn't produce an acceptable answer, the ICALL system then subject their answer to a series of NLP processes (e.g., Chinese-word segmentation, syntactic parsing) in order to identify the problematic areas and provide relevant mediation based on the result of that analysis. For instance, if the problematic area is related to the grammatical object, the next mediation provided by ICALL system targets that particular issue and becomes more specific: "OK. So can you take a look at the grammatical object of the verb phrase?" Figure 1 depicts the core algorithms of the Chinese ICALL program, and Figure 2 shows the web-based interface where the participants interact with the ICALL system.

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INSERT FIGURE 1 AND 2 ABOUT HERE
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The graduated mediation provided by the ICALL system is contingent on learners' response to the question. In other words, the mediation does not have a fixed number of level, but rather depends on the type of errors learners make. The ICALL system always provide the most implicit mediation when a learner fail to answer the question correctly on the first attempt. The subsequent mediation is based on analysis of different aspects of the syntactic elements of the Chinese *ba*-construction, a grammatical structure that is known to be challenging to L2 learners (Jin, 1992; Wen, 2012). The analysis focuses on the *ba*-particle, the perfective *–le*, the word order, the grammatical object, and the verb complement (see Figure 1). Interested readers can consult Ai (2017) for more information about the ICALL system.

4.3 Tracking Learner Development

In order to trace learner development as they completed the tasks in the ICALL system, the participants' complete interactions with the ICALL system were recorded using video screen recording software. In addition, the ICALL system logged learners' input and the time they took in completing each question. The post-enrichment interviews were recorded and transcribed. In our project, a human tutor was also present while learners completed tasks in the ICALL environment. To analyze the effectiveness of the ICALL system, we first viewed the video and audio data in order to identify instances in which the system identified (or failed to identify) the participants' problematic areas. We then examined the participants' interactions with the system as captured by the logging function, which allowed us to reconstruct the moment-by-moment edits made by the participants as they completed the English–Chinese translation task. Finally, we transcribed and examined the interview data in which the participants spoke about their perceptions of the ICALL system's pedagogical value in terms of helping

them navigate the various aspects of the *ba*-construction. In what follows, we present a snapshot of the interactions between the ICALL system and two learners, Larry and Chris, to illustrate how L2 development can be tracked in the ICALL system as well as some of the challenges that the system may encounter.

4.3.1 A snapshot of Larry's interaction

Larry was a third-year university student majoring in classics and ancient Mediterranean studies and ancient languages. He had studied Spanish for six years and had a one-semester sojourn in Greece learning Modern Greek. At the time of the study, Larry was taking a course on Chinese film and another on Chinese classical novel. The analysis presented below focuses on Larry's interaction on the second translation task: "My roommate fixed my bicycle yesterday afternoon." Table 1 presents the moment-by-moment changes or edits Larry made for completing the translation task in the ICALL environment.

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INSERT TABLE 1 ABOUT HERE
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In his first attempt at translating the sentence, Larry actually produced a complete *ba*-construction with all the components needed (e.g., subject, *ba*-particle, object, verb, and the perfective marker *-le*). He was also confident about his answer, with a confidence level of 4 out of 5. The only issue with his answer was that he failed to provide the resultative component 好 "good" for the verb 修 "fix", a required syntactic component for the Chinese *ba*-construction in this situation. As shown in Table 1, the first mediation provided by the ICALL system was the most implicit. Without explicit information, Larry was unsure about the location of his error, and suspected that it had something to do with the possessive *de*. Therefore, in this second answer to the question, he deleted the two possessive markers. Predictably, his second answer was not accepted. The second mediation provided by the ICALL system was more specific and asked about the result of the verbal action (see row 2 in Table 1). Upon receiving this more specific feedback, Larry was able to immediately identify the location of the issue and proposed the correct answer and said "Oh, so like, ah (+), he completed (+) the fixing, because (++) if, if you fix it, it's better now, like 修好 'fix-good', I guess I'll try that." This is a crucial point as it reveals that (i) the ICALL system successfully identified Larry's problematic area—the missing resultative component for the verbal phrase—and provided relevant and useful information to Larry; and (ii) with the provision of this critical piece of information, Larry was able to not only self-correct his error, but also verbalize the reason behind his revision, demonstrating his developing understanding of the verbal complement requirement of the Chinese *ba*-construction.

With regard to difficulties that remain in the ICALL system, we note that this was not the end of Larry's second translation task. Owing to the design of the accepted answers that could be recognized by the ICALL system for the second question, Larry's answer was not accepted because it did not include the possessive marker *de*. *De* in this case is optional (e.g., 我[的]家 wo [de] jia, "my home"), and Larry's answer is perfectly acceptable in Chinese, but was misidentified as problematic by the ICALL system. In response, Larry considered the possibility of relocating the perfective marker *le* to post-verbal position from the post-sentential position. Sensing Larry's difficulty in identifying this "non-error", the tutor explicitly pointed out that a possessive *de* is needed between an adjective and a noun phrase in Chinese. Larry then revised his answer and submitted it again, and the ICALL system finally accepted his fourth attempt as correct.

4.3.2 A snapshot of Chris's interaction

Chris had studied Chinese via teleconferencing for five years in high school. He and his brother both studied Chinese, and they spoke to each other from time to time in Chinese "in very small amounts." At the time of the study, Chris was enrolled in Level 3 of a college-level Chinese course. Compared to Larry's interactions, Chris's experience was more onerous. He spent more time completing the five translation questions, had the most frequent attempts, and required the most extensive feedback both from the ICALL system and from the tutor, as compared to the other participants. Table 2 summarizes the moment-by-moment changes Chris made in his effort to translate the first English sentence: "Teacher Zhang quickly wrote answers to those questions on the blackboard."

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INSERT TABLE 2 ABOUT HERE

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As can be seen, it was not until Chris's tenth attempt that the ICALL system accepted his answer as correct. It should be noted, however, that his ninth answer was correct, but as with Larry, the ICALL system failed to recognize it as such because it was not among the predefined acceptable answers. As Chris worked towards producing a correct *ba*-construction for the translation task, he corrected some errors during each interaction with the ICALL system, but also introduced some new ones at the same time. This indicates that his understanding of the various aspects of the *ba*-construction was still in the process of development. The iteration-by-iteration data show that the mediation provided by the ICALL system was helpful in some aspects (e.g., the first implicit prompt helped Chris to self-correct some linguistic issues), but not in others. For instance, during Chris's third attempt at providing an acceptable answer, the mediation provided by the ICALL system was not very helpful. In fact, it confused Chris because he knew that he needed to remove the resultative 完 "complete". However, if he had made changes based on the feedback provided by the ICALL system, he would have arrived at the exact same answer as in his second attempt. This reveals some of the challenges that the ICALL system encountered in providing helpful and appropriate mediational feedback to language learners. In this case, the ICALL system was not designed to account for the subtle differences between resultative verb compound (i.e., 写完 "write-finish") and verb plus prepositional phrase (i.e., 写在...上 "write onto..."). It also needs to be noted Chris's ninth answer was already correct, but because it was not one of the predefined acceptable ones, the ICALL system did not recognize it as such. This challenge speaks to the difficulties for ICALL system to predict correct (and incorrect) answers produced by language learners, a point we discussed earlier.

Chris's process of entertaining multiple revisions before submitting his "final version" of the answer reveals yet another limitation of the ICALL system. For instance, in his first version of the translation, Chris was uncertain about the resultative component of the verb action 写 "write," so he tried 写放 "write-place." However, he quickly abandoned this idea, and replaced it with 写上 "write-onto," before submitting his "final answer" during this first interaction with the ICALL system. There were two things that were especially noteworthy. First, although the ICALL system can track learners' microgenetic changes by logging their moment-by-moment edits in their language production, the web-based system as currently implemented was only able to record learners' very last change when they click the submit button. While it is possible to implement a key-logging function in the ICALL system, the real-time changes of the thought processes, in our view, is perhaps better suited to be captured by screen video technology. Second, it was not uncommon to see learners correcting different linguistic issues at multiple locations during each iteration with the ICALL system. The ICALL system designed in this study, like many other ICALL systems, takes an iterative approach and provides feedback on

only one language point at a time. This design was intentional: the idea was to enable the participants to focus their attention on one linguistic aspect related to the *ba*-construction at any given time.

In summary, our analysis of the data shows that the graduated approach to providing mediation was mostly effective in identifying the participants' problems in regard to various syntactic elements of the *ba*-construction and in providing pertinent and meaningful mediation for them to revise their answers. For example, it targeted Larry's problematic area on resultative component of the verb phrase accurately and provided appropriate mediation, and helped Larry work out an acceptable answer that includes the correct components of the grammatical construction. In this way, it served as an effective pedagogical tool in regard to mediating the participants' progress in understanding and using the *ba*-construction

4.4 Discussion

Research on L2 microgenetic development has traditionally been conducted in the context of moment-to-moment interactions between language learners and teachers in face-to-face scenarios. The study reported in this chapter shows that such developmental trajectory can also be traced in computerized (web-based) ICALL system, between learners and computers. As the analysis shows, when the feedback provided by the ICALL system became more specific and targeted at specific syntactic component of the *ba*-construction, the participants were found to be able to identify the location of the errors and often self-correct such errors. This result is in line with Han (2002) who reported that when targeted at specific L2 forms, feedback can be especially useful in helping learners notice mismatches between their own language production and target-like forms. Similarly, Heift (2010) also found that L2 German learners showed significant uptake for error-specific feedback over generic feedback type.

The analysis also showed that the ICALL system has occasionally failed to locate the source of learners' error and consequently required the tutor to step in to mediate the situation. It needs to be noted that the presence of the tutor in the ICALL system was not an intended feature of the original design, and it may have hindered the effectiveness of the ICALL system being used as a stand-alone computer program. It did, however, highlight one of the challenges Amaral and Meurers (2011) observed regarding the range of information that can be considered by an ICALL system (language) versus a human instructor (the learner, the task, and the language). While a completely independent ICALL system may be desirable, in technology-mediated learning environments, it is not entirely unusual to have an instructor available to help learners navigate the various technology and non-technology-related hurdles in L2 learning (Ai, 2017). Until the day that advancement in computational linguistics can help account for the various learner- and task-related information, it might be useful to consider a symbiotic relationship between the computer and the human teacher, whereas the ICALL system can still be used (i) to provide immediate and graduated mediation to learners on a large number of cases it can handle, and (ii) to automatically track user performance data on the background, while the human instructor's knowledge, experience, and flexibility can be capitalized in cases where ICALL systems struggle.

A more technical recommendation for practice pertains to the use of bridging software to ensure cross-programming language interoperability in ICALL system design. In the present study, we encountered a challenge related to programmatic communication between the Java-based Stanford NLP software and the Python-based ICALL system in a web-based environment that calls for a relatively short response time. When a learner submits an answer, the website, which was written in the Python programming language, needs to call the Stanford NLP function in order to parse the underlying syntactic structure of the submitted sentence. Because the Stanford NLP programs are written in Java, they cannot be directly called by Python programs. Inter-process communication (e.g., Python subprocess module) would entail the initialization, execution, and termination of a Java Virtual Machine (JVM) each time a user submits a sentence to process. The communication between the two

programming languages in real-time is the core issue, which was resolved by using a bridging software called PY4J, a software library written in Python and Java that allows Python to utilize Java functions running natively in JVM. This, in effect, eliminated the need for the NLP tools to load the time-consuming large dictionaries into the computer memory each time a learner submits an answer to the system, thereby shortening the response time from 15+ seconds to only a few seconds. From a technological point of view, the use of such bridging software packages has broader significance to the field of ICALL, as it opens up the possibility of leveraging a wide variety of existing NLP software packages that may or may not be available in the particular programming language and the related environments in which an ICALL system is developed.

5. FUTURE DIRECTIONS

This chapter explored the synergy between SCT and ICALL by discussing a graduated approach to mediation (Aljaafreh & Lantolf, 1994) implemented in ICALL environment. By examining data logged by the web-based system, we showed that it is possible trace learners' microgenetic L2 developmental processes during a short learner-computer interaction. We also showed that mediation provided by the ICALL system can be contingent on analysis of learners' language production, not just recognition. To better help learners improve language learning, one productive area for future study to explore is to "fine-tune" (Poehner, 2007, p. 325) the mediations based on learners' response. For example, a fine-grained hinting system can be designed to perhaps highlight only the problematic segment of learners' answer, thus helping them reduce confusion and pinpoint errors more quickly. Another area worth further examination in the potential synergy between SCT and ICALL is combining NLP techniques, and principles in interventionist approaches to DA (Lantolf & Poehner, 2004) in an ICALL environment. For example, research such as the Leipzizg Learning Test (Guthke, 1982), and its computerized version (Guthke & Beckmann, 2000) will likely benefit from incorporating advanced computational linguistics and NLP techniques such that the provision of mediational assistance can be based on an analysis of learners' language production, rather than on a standardized set of feedback. Finally, as Ziegler et al. (2017) showed, ICALL systems can be particularly suited to collected substantial amount of data for language learning research. Future research can explore ways to integrate ICALL systems in foreign language teaching programs in order to harvest volumes of longitudinal data in order to deepen our understanding of L2 developmental processes.

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Figure 1

Core algorithm of the Chinese ICALL program (Ai, 2017)

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If the learner's answer is already correct:
    Set mediation as "Congratulations! That's exactly right!"
    Log meta-information into relational database
    Display mediation to the learner
Else:
    Perform Chinese Word Segmentation
    Perform Syntactic Parsing on segmented text
    If this is the first answer by the learner:
        Set mediation as "Hmm, can you take a look at it again?"
    Else:
        If it does not have the ba-particle:
            Set mediation as "Okay, so what particle do you think that we might need here?"
        If it does not have the full-stop punctuation:
            Set mediation as "A complete sentence should have a ...?"
        If it does not have the perfective marker -Le:
            Set mediation as "Hmm, so has the action completed yet?"
        If it does not have the correct verb complement:
            Set mediation as "Okay, so what's the result of the verbal action?"
        If the ba-VP is placed before the ba-NP:
            Set mediation as "Are you sure that the word order is okay?"
        If the ba-NP is correctly translated:
            Set mediation as "Can you take a closer look at the grammatical object?"
        Else:
            Set mediation as "You might be right already, but the translation you provided is not
                              exactly what I have on file. Can you please try it one more time?"
    Log meta-information into relational database
    Display mediation to the learner via web interface
```

Figure 2
Web-based interface of the ICALL program

Table 1

Larry's moment-by-moment changes and mediation he received.

#	Answer	Problematic Areas	ICALL Mediation	Tutor Mediation
1	昨天下午我的室友把我的自行车修了。	Missing resultative verb 好 "good" in the RVC.	Hmm, can you take a look at it again?	N/A
2	昨天下午我室友把我自行车修了。	Missing resultative verb 好 "good" in the RVC.	Okay, so what's the result of the verbal action?	Answered Larry's question on the possessive de.
3	昨天下午我室友把我自行车修好了。	Missing possessive de	Can you take a closer look at the grammatical object?	Pointed out that possessive de is needed between an adjective and a noun phrase.
4	我的同屋昨天下午把我的自行车修好了。	N/A	Congratulations! That's exactly right!	N/A

Table 2

Chris's moment-by-moment changes and mediation he received.

#	Attempted Answer	Problematic Areas	ICALL Mediation	Tutor Mediation
1	张老师把那些问题快速的写上在黑板	(1) grammatical object incorrect; (2) de in adverb incorrect; (3) directional word 上 misplaced * (4) need punctuation; (5) lacking perfective marker –*le* *	Hmm, can you take a look at it again?	N/A
2	张老师把那些问题快速的写上在黑板了。	(1) grammatical object incorrect; (2) de in adverb incorrect; (3) directional word 上 misplaced *	Okay, so what's the result of the verbal action?	N/A
3	张老师把那些问题快速的写完上在黑板了。	(1) grammatical object incorrect; (2) adverb de "的" incorrect; (3) directional word 上 misplaced *	Okay, so what's the result of the verbal action?	N/A
4	张老师把那些问题快速的写上在黑板了。	(1) grammatical object incorrect; (2) adverb de "的" incorrect; (3) directional word 上 misplaced *	Okay, so what's the result of the verbal action?	Draw participants' attention to the fact that "on the blackboard" is the result, not "finished writing."
5	张老师把那些问题的答案快速的写上在黑板了。	(1) adverb de "的" incorrect; (3) directional word 上 misplaced *	Okay, so what's the result of the verbal action?	Points out that what is written is "answers to the question," not "question" itself.
6	张老师把那些问题的答案快速地写上在黑板了。	(1) directional word 上 misplaced *	Okay, so what's the result of the verbal action?	Draw Chris's attention to "快速的"
7	张老师把那些问题的答案快速地写在了上黑板。	(1) directional word 上 misplaced *	Okay, so what's the result of the verbal action?	Tutor apologized that the computer prompt is not very helpful here, and asked Chris to try to

#	Attempted Answer	Problematic Areas	ICALL Mediation	Tutor Mediation
				move something. Also directed Chris's attention to directional word.
8	张老师把那些问题的答案快速地写了在黑板上。	(1) directional word 上 misplaced *	I'm afraid I don't fully understand your answer :-(Please consult with your instructor.	Focusing on the location of the directional word. Give an example of 书包里 "Inside the backpack."
9	张老师把那些问题的答案快速地写在黑板上了。	N/A	Has the action completed?	Can you try it again?
10	张老师把那些问题的答案快速地写在了黑板上。	N/A	Congratulations! That's exactly right!	Can you put the –le at a different place?

Note: * denotes areas directly related to the *ba*-construction; dark shaded areas indicate the places where changes were made.

BIOGRAPHICAL NOTE

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