Computer Assisted Vocabulary Learning: Framework and Tracking User Data

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ABSTRACT

This article presents a framework for categorizing computer assisted vocabulary learning (CAVL) applications which can be divided into two broad categories: lexical programs/tasks and lexical resources/aids. There are currently three major types of lexical resources/aids: open Google searches, electronic dictionaries and lexical concordancers; they provide learners with access to meaning and other lexical information. Lexical programs/tasks can be further divided into four types: incidental learning with lexical glosses, CMC lexical-based tasks, computerized vocabulary exercises, and dedicated CAVL programs. Such a classification is made based on the prominence each gives to vocabulary learning in terms of tool/tutor, implicit/explicit learning and meaning/form focus. The future generation of CAVL applications should be flexible and compatible with the fast-developing ubiquitous online technologies. Equally important is the user tracking system built into each application, as tracking data can reveal how learners actually interacted with the learning system (Fischer, 2007; 2012). A review of tracking systems used in CAVL shows that multiple technologies/means have been used in tracking user actions but further research needs to focus on the identification of the key user actions related to learning outcome. Only with a good tracking system can CALL effectiveness be proven, useful design features be identified, and the appropriate applications be selected.

KEYWORDS

Computer assisted vocabulary learning, Tutor, Tool, Tracking, User actions

INTRODUCTION

Vocabulary learning is considered to be one of the most crucial components in learning any language. Most CALL programs place a considerable emphasis on vocabulary learning implicitly or explicitly. Nonetheless, few efforts have been made to aim for a clear conceptualization of computer assisted vocabulary learning (CAVL) so that it can be developed into a distinctive sub-domain of CALL.
The objectives of this article are two-fold. The first is to review currently available CA VL applications with a view to updating an earlier CA VL framework constructed by Ma (2009) and forecasting the future generations of CA VL applications. The second is to take a snap shot of the tracking technologies/systems used in existing CA VL applications. A good tracking system is an inseparable component of a CALL/CA VL application. It can record an array of user actions for learners to manage and monitor their learning as well as provide an intelligent learning system for evaluation purposes based on which the system may recommend appropriate learning paths for learners.

**KEY ELEMENTS IN CA VL DESIGN**

Although most of the early CALL applications were dominated by vocabulary exercises (e.g., gap-filling, text-reconstruction, vocabulary games), their efficacy was often questioned due to the simplicity of exercise type and a lack of pedagogical design of learning activities. Goodfellow (1995) raised a few concerns regarding the design of CA VL programs, two of which are worthy of more attention, i.e. vocabulary learning should be explicit in CA VL and the design should be based on learning theories specific to vocabulary learning. By examining the key factors that have shaped CA VL development over the years, Ma (2009) proposed that CA VL applications should possess a number of pedagogical criteria: 1) the learning activities should provide opportunities for learners to notice the word form and access its meaning as well as connect the two; 2) at least two types of linguistic information, visual and aural, should be presented; 3) the program should incorporate or be linked to electronic dictionaries or lexical concordancers; and 4) explicit focus should be put on the target items so that learners can rehearse, manipulate or reorganize the lexical information.

Levy (1997) discussed the nature of the computer technology in CALL applications, such as whether the computer acts as tutor (e.g., teacher) to guide the learning or as a tool to facilitate learners’ performance. This tutor/tool distinction has had a profound influence in guiding CALL and CA VL development. Equally important is the on-going implicit/explicit discussion on vocabulary learning: whether vocabulary items should be acquired through repeated exposure to language (in textual reading mostly) or else learned with explicit attention paid to the word form and its various aspects (e.g., collocation or usage). In L2 acquisition, the former is frequently equated with incidental learning and the latter intentional learning (Ma, 2009). These key elements in good CA VL design will be further discussed in the next section.

**A NEW CA VL FRAMEWORK**

Based on the one put forward by Ma (2009), a new framework is constructed which incorporates the aforementioned pedagogical considerations as well as considering the current technology advancement, i.e., the ubiquitous nature of online technology and the rapid growth of language learning software/applications accompanied by constantly updated mobile devices such as smartphones.
or tablet PCs. Currently, we are in the tutor and tool integrated stage for CAVL; we need both tutors and tools to make the vocabulary learning more efficient. In a similar vein, implicit and explicit learning should be combined in CAVL so that learners have a balanced chance for frequent language exposure and paying specific attention to word forms and the various types of lexical information. An overview of this updated framework is provided in Figure 1. Lexical programs/tasks provide the mainframe work station for CAVL while lexical resources/aids can be integrated into the former as a necessary lexical help system, or as part of the “meaning technologies” defined by Hubbard (2001).

Figure 1: A New Framework for CAVL Applications (updated from Ma, 2009, p. 183)

### Lexical Resources/Aids

These refer to various meaning technologies for learners to access the meaning of the new vocabulary items. They include open online resources such as the search functions offered by Google, Wikipedia, various thesauruses, web-based or localized electronic dictionaries and various corpus-based online lexical concordancers. These resources are facilitative in nature and thus primarily tools. Electronic dictionaries have a number of potential advantages over paper dictionaries. First, the electronic dictionary can respond to learners’ input intelligently. Second, only necessary lexical information is displayed and extra information can be displayed upon request. In addition, lexical information can be accessed in multiple channels simultaneously: textually, pictorially, and aurally. The electronic dictionary can also simulate the human lexical memory by organizing lexical entries as synonyms or hyponyms (e.g., WordNet developed by George Miller, available at [http://wordnetweb.princeton.edu/perl/webwn](http://wordnetweb.princeton.edu/perl/webwn)). At present, the most common
network search engine, Google, has become the largest open “dictionary” in the sense that by entering a target word the user can end up with a large number of definitions or translations, either from existing online dictionaries or provided by organizations or individuals. This has considerably shortened the time of looking up words in an electronic dictionary by which the learner would open the website for the online dictionary and type in the word and then click on the search button.

Unlike with an electronic dictionary, normally neither the word meaning nor the usage is given directly via corpus search in popular lexical concordancers that accommodate authentic and lively language use. A free and very useful website (http://corpus.byu.edu/), developed by Mark Davies from Brigham Young University, hosts a number of important corpora of enormous size, including the 100-million-word British National Corpus (BNC) and a 450-million-word Corpus of Contemporary American English (COCA). In addition, the language data are differentiated by genres: spoken, fiction, magazine, newspaper, academic writing, etc. The website Compleat Lexical Tutor (http://www.lextutor.ca/concordancers/) developed by Tom Cobb incorporates multilingual corpora: English, French, German and Spanish. By entering a key word, the concordancer can generate many lines that contain the key word and the learner needs to infer the word meaning or observe the pattern use from the surrounding contextual clues. Such concordancers have provided learners with a large amount of authentic language input in which the target item occurs. Whether the concordancers can be used efficiently depends on several factors, such as learner perception, learner proficiency, teacher help, instructional guidance and, most importantly, what vocabulary exercises are designed based on the concordanced items (Ma, 2009). Cobb (1997), Horst, Cobb and Nicolae (2005), Hafner and Candlin (2007) and Pérez-Paredes, Sánchez-Tornel, Calero, & Jiménez (2011) have all provided good examples of ways of integrating concordancers into CAVL applications.

**Lexical Programs/Tasks**

Lexical programs/tasks can be broadly divided into four types: *incidental learning with lexical glosses, CMC lexical-based tasks, computerized vocabulary lists/flashcards/exercises, and dedicated CAVL programs*, depending on the prominence they give to vocabulary learning in terms of tool/tutor, implicit/explicit learning, and meaning/form focus. When reading online texts (Chun & Plass, 1996; Laufer & Hill, 2000) or listening to online audio texts (Jones & Plass, 2002), the primary concern of the learner is to comprehend the text and, as a by-product of the comprehension process, some words may be acquired, but this is usually limited to recognition. The learner may consult new words via glosses, hyperlinks or checking an electronic dictionary. The learning of vocabulary items is primarily implicit because there is no explicit attention to the word forms. Learners only need to scroll up and down pages or click on buttons; the main function of this type of application is to execute the learner’s command. Such applications are essentially tools but can be easily integrated into other tutorial applications.

So far, two types of CMC tasks, asynchronous email/text message and synchro-
nous communication (chatting), are widely studied for their potential in promoting L2 development. Largely within the framework of interactionist SLA, particularly Long’s interaction hypothesis (1996) and Swain’s (1995) pushed output, research into CMC has shown learning benefits in reading and writing, communication skills, morphosyntactic development, sociolinguistic competence, learner production, learner participation, learner motivation, etc. (De la Fuente, 2003). Only a few studies (e.g., De la Fuente, 2003; Smith, 2004) have focused on lexical acquisition, the reason being that in the communication process, it is the negotiation of meaning — noticing input features, modified input, positive or negative feedback and modified output (or pushed output) — that is supposed to be beneficial. But if carefully designed, CMC tasks can be scheduled for learners to practice using the previously learned lexical items after incidental learning or using more explicit types of CAVL applications.

There are several types of computerized vocabulary exercises (CVEs). The simplest one is electronic lists/flashcards arranged alphabetically, semantically or according to topic. A more complicated electronic flashcard is SuperMemo (http://www.supermemo.com/index.htm) which is based on the learning theory of spaced repetition and was originally developed by a group of Polish computer scientists in the 1980s. It has been constantly updated and the most recent version is SuperMemo 2008. Learners need to input all the lexical information in two parts, a question as a retrieval clue and the target word as the answer, e.g., What do you call the brother of your husband or wife? Brother-in-law. While retrieving the target item, the learner is required to rate the familiarity of the item. The system will store the rating and schedule how this item shall be reviewed based on spaced repetition. A similar software, Anki (http://ankisrs.net/index.html), developed by Damien Elmes, works on a similar principle but adopts a much more user-friendly interface. In addition to providing a platform for storing and testing self-input vocabulary items as in SuperMemo, the web version of Anki has been preloaded with a set of vocabulary lists at various levels for learners’ convenience. Another type of CVE is a simple exercise in which learners are instructed in a specific vocabulary memorization method, such as Linkword, which uses the keyword method, Reviewing the Kanji which utilizes linking to a concrete image, or the Visual Understanding Environment, featuring graphic representation (Godwin-Jones, 2010). One type of CVE is similar to a simple tutor, using a variety of more contextualized vocabulary exercises, including matching definitions or gap-fillings, to help learners rehearse newly learned items based on a specific learning theory (e.g., Allum 2004; Stockwell, 2007). Generally, all types of CVEs can be useful in consolidating vocabulary knowledge since systematic rehearsal is necessary for keeping the words in long-term memory. The computer can evaluate the learner input and give some feedback, thus providing the exercises with some tutor features. The learning is primarily explicit as considerable attention is paid to both the word form and the word meaning.

If each of the previous types of CAVL applications offers some opportunities to address a different aspect involved in the vocabulary learning process in bits and pieces, dedicated CAVL programs are the converging locale where all necessary
QING MA

procedures involved in learning are incorporated. In this way, dedicated CA VL programs are particularly geared to vocabulary learning in a more comprehensive and systematic way. Vocabulary learning is both contextualized and itemized; it is both meaning and form focused (explicit learning); it combines tutor with tools; it covers both the initial learning process and the subsequent rehearsal. Ideally, the learning benefits may go beyond simply learning vocabulary items: cultural knowledge can be promoted and vocabulary learning strategies inculcated. Such dedicated CA VL applications include Wordchip developed by Decoo, Heughebaert, Schonenbert, and Van Elsen (1996), Lexica developed by Goodfellow (1999), CAVOCA developed by Groot (2000) and the WUFUN software described in Ma and Kelly (2006) and Ma (2007; 2008). The WUFUN software starts with a preview of the learning context in multiple media input: visual, pictorial and textual; a series of pictures accompanied by spoken and written sentences are presented to learners. Then the learner can look up any target vocabulary item in a mini built-in dictionary. This follows the reading of the full context, the story containing all the target items. After this, a number of memory strategies (e.g., verbal association, imagery, rhyming and alliteration) are introduced to help learners remember these target items, the aim being to connect the new word form to the meaning. Strategy training is followed by a number of contextualized exercises for learners to practise using the target items both receptively and productively. At the end, some idioms and culturally-related humour are introduced to learners with a view to arousing learners’ awareness and appreciation of cultural elements in language learning.

**TRACKING USER ACTIONS IN CALL**

Tracking user actions/interactions in CALL applications has been practiced and valued by a growing number of researchers (Chapelle, 2001, 2003, 2005; Fischer, 2007, 2012; Garrett, 1995, 1998; Liddell & Garrett, 2004) for various reasons. Fischer (2007, p. 411) showed convincingly that tracking user data is a form of “ethnographic research” in the CALL community. Chapelle (2001, 2003) put forward a process-oriented approach to CALL empirical evaluation that emphasizes the analysis of learner behaviors on the computer, including mouse clicks, keyboard activities, cursor movement, use of resources, etc. In addition, Fischer (2007) summarized other reasons for tracking users’ data: (1) addressing micro level design features; (2) improving instructional design in courseware; (3) promoting learner autonomy or providing learner training; and (4) verifying learner self-reported data with actual recorded data.

User actions can be tracked by various technologies or means. The tracking system can be built into the application, as has been shown by Goodfellow (1999), Laufer and Hill (2000), Hegelheimer and Tower (2004), Stockwell (2007), and Ma (2008). As reported by Fischer (2007, 2012), users’ actions can also be recorded by a plug-in tracking device, such as Hypercam, Camtasia, and Snapz Pro, that can monitor and record a range of data, including mouse clicks, key presses, cursor movement and texts entered, to be assembled into a log file for research
purposes. In addition, Abdel Latif (2008) reviewed various plug-in applications traditionally used for investigating the writing process, which showed great potential for CAVL applications. Both built-in and plug-in tracking systems have the advantage of “unobtrusively observing students’ behavior” (Fischer, 2007, p. 411). CALL researchers have also used other more direct means, such as video or tape to record user actions (De Ridder, 2002; Hémard, 2004), or simply did so manually (Desmarais, Duquette, Renié & Laurier, 1997). In the following section, based on the previously presented CAVL framework, a number of specific CAVL applications will be examined, focusing on the tracking systems and technologies.

TRACKING SYSTEMS IN CAVL APPLICATIONS

Lexical Resources/Aids

Tracking open resources such as Google search and use of Wikipedia could be made possible by use of a plug-in device to record the words or phrases searched. Many studies have shown that use of electronic dictionaries is the prerequisite for incidental learning to occur (Chun & Plass, 1996; Hulstijn, Hollander, & Grendianus, 1996; Knight, 1994; Laufer & Hill, 2000). Nowadays, most electronic dictionaries are equipped with multiple functions apart from simply accessing meaning and use. The user can record the word looked up, enter it into a personalized word list and edit the notes for it as in the KinSoft Dictionary (http://www.iciba.com/) or the Youdao Dictionary (http://www.youdao.com/), the two most popular bilingual dictionaries in China. In this sense, electronic dictionaries have combined the traditional look-up function with the recording function offered by electronic notebooks. Browsing the personalized word list, learners can self-test these previously encountered words and consolidate the meaning-form mapping. Most concordancers incorporating corpora are originally designed for research purposes, and there is usually no inherent tracking system. However, a recent study by Wible, Liu and Tsao (2011) has shown an interesting plug-in browser-based application, Collocator, which allows learners to make use of corpus data for learning collocations in online texts. The user can install Collocator in the toolbar on an Internet browser and choose to activate or deactivate it when browsing online pages. When in activation, it can automatically extract all the collocations in the online text and display a list. Then the learner can select any of these listed collocations, which will bring the user’s attention to the collocations which have actually appeared in the text by automatic highlighting techniques. A built-in tracking system records various user actions, such as browsing behaviors and activation of the application. The webpages visited and the collocations studied are also retained in the log file.

Lexical Programs/Tasks

Incidental learning with lexical glosses

Laufer and Hill (2000) investigated how both Israeli and Hong Kong university learners made use of five different types of glosses for target words in an online
reading text: (1) word pronunciation, (2) meaning in English, (3) L1 translation, (4) lexical root, and (5) extra information (various forms of the word, register, collocation, synonyms, etc.). Each time the student clicked on a type of gloss, the built-in log system would record this look-up behavior. Finally, for each student there was an individual log file which presented all the words looked up and what look-up behaviors were associated with each word. The learning rate ranged from 33.3% to 62% at the recognition level. The students’ total look-up behaviors were correlated with vocabulary retention and a weak correlation (.35) was found for the Israeli group only but not for the Hong Kong group. It is likely that these five types of look-up behavior differ from each other qualitatively in terms of their contribution to vocabulary retention. Correlating the total types of look-up behaviors with vocabulary retention may not yield a clear relationship. Stronger correlations might be obtained if each different look-up behavior were correlated with vocabulary retention separately.

CMC lexical-based tasks

In CMC tasks, two conditions need to be met for lexical acquisition to occur. The learner should first notice a lexical gap from the partner’s input. The learner then shows a non-understanding and requires the other interlocutor to explain or rephrase the unknown item. Through this interaction process, the learner establishes the initial meaning-form mapping. If the learner uses this new item in subsequent output, this equates with “pushed output” (Swain, 1995) and can further consolidate the mapping process. In this sense, lexical-based tasks need to be carefully designed, e.g., through information-gap activities, to allow more information exchange which focuses on both meaning and form, as shown by De La Fuente (2003) and Smith (2004). The default approach to tracking user actions in CMC tasks is to study log files, the learner output left in the chatting boxes, and to look for evidence that shows learners have noticed, elaborated, and interacted with the target items. However, Smith (2008, p. 89) pointed out “chat logs… fail to capture a significant portion of the data” and showed that simply relying on chatting logs could miss many unrecorded user actions, such as self-correction of linguistic errors or inappropriate language uses. In a similar vein, O’Rourke (2008) argued that the log files on their own are far from sufficient to capture learner data and proposed the use of a variety of means to track learners’ communications in CMC, including their retrospections, keystroke logs, video screen-capture, video recording and eye-tracking. A recent article by Smith (2012) has shown that eye-tracking can be a valuable tool to investigate learners’ noticing of target language features in CMC tasks. Although we know there is an ample array of user actions that can be tracked, very few studies have been carried out to investigate the actual relationship between these various user actions and the actual learning outcome, for example vocabulary retention, in CMC tasks. We are left without knowing whether all these recorded user behaviors are equally important with respect to lexical acquisition.
Computerized vocabulary lists/flashcards/exercises

Different from the previous meaning-focused learning in CMC tasks, this type enables learners to focus more directly on the target forms either in contextualized or decontextualized learning. Stockwell (2007) presented an interesting intelligent tutor in which the user tracking system includes three components: (1) results of all exercises completed; (2) an item-specific profile for the learner (e.g., degree of familiarity with the item and the type of exercise completed for the item); and (3) an overall profile for each learner’s vocabulary level, number of trials, total study time, scores, and the task type. As with the CMC types, no efforts were made to establish the relationship between these learning behaviors and learning outcome, therefore it remains unclear whether all these tracked user actions can equally contribute to learning outcome or not.

Dedicated CAVL Applications

Given the comprehensiveness and complexity of the various learning tasks included, a range of learner data can be tracked in this type of application. The study by Goodfellow (1999) showcased how a number of user actions could be tracked and analyzed in a dedicated CAVL application: Lexica. This program consists of three sequential learning stages: selection, lexicon-building, and testing. In the first stage, learners select the unknown words while reading through online texts. They then assign these unknown items to one of the three pre-defined categories: meaning, form and context. In the second stage, learners are provided with different means to access lexical information regarding the selected items, including meaning, related items, translations, collocations via an online dictionary and a lexical concordancer. In the last stage learners are tested on the recorded items by a cloze test generated from the original reading text or the corpus hosted in the lexical concordancer. A number of user actions are recorded in the system: (1) total time spent on the learning, (2) items selected and the total number, (3) subgroup titles for items (e.g., ‘bad feelings’ or ‘human body’), (4) items accurately retrieved in the test, and (5) learning rate per hour. The results showed that not all learners followed the designed learning sequence which aimed at promoting a deep word processing level. Some participants spent considerably more time in retrieving the word items in the third stage than in processing the word items in the previous two stages. Although a few participants managed to achieve a full learning rate (100%), i.e., retrieving all items selected, Goodfellow (1999, p. 123) claimed that these learners actually adopted a shallow learning approach which only focused on “the word level, L1 equivalence and memorization” and “may indicate the absence of quality”.

The WUFUN software described by Ma (2007, 2008) comprised reading texts, a mini-dictionary, a tailor-made section on memory tricks (mnemonics), receptive and productive exercises, an idiom session and a culture/humor-related component. The built-in tracking system can track 9 types of user actions: (1) the number of pages viewed; (2) the number of words looked up; (3) the number of memory
tricks studied; (4) the number of exercises completed; (5) the time spent on doing exercises for the first trial; (6) the exercise score obtained for the first attempt; (7) the final scores for the exercises after several attempts; (8) the number of target words that occurred in users’ answers to exercises; (9) the total time spent in studying the unit. In a subsequent correlation study, Ma (2008) showed that only three out of these nine user actions can positively account for vocabulary retention: the number of words looked up, the number of target words that occurred in users’ answers to exercises and the final scores for the exercises. If the first of these three pertinent user actions indicated that learners had actually accessed the meaning of the unknown items, the last two provided evidence for the consolidated meaning-form mapping in language output. This study drew attention to the fact that tracking user actions is not a question of the more the better. The identification of the most relevant user actions is crucial; the selected user actions should manifest necessary levels of vocabulary processing and be linked to “the cognitive processing of the target linguistic item” (Ma, 2008, p. 110).

CAVL APPLICATIONS AND TRACKING IN THE UBIQUITOUS ONLINE TECHNOLOGY ERA

The interpretation of the current tool and tutor integrated stage is two-fold. First, we could combine both tutor and tool in a given CAVL application as shown by the aforementioned dedicated CAVL applications. Secondly, tool and tutor can be developed separately and learners can make use of both types to facilitate different aspects of vocabulary learning. Although the previously discussed dedicated CAVL applications reflected good criteria in pedagogical design and had the potential to address various features of vocabulary learning, it was time-consuming for developers to design all the learning packages and the pre-selected learning activities, which may not be suitable for all individual learners. In the current ubiquitous online technology era where people frequently search for and extract learning information from the internet, what makes more sense is to develop a powerful CAVL template which helps users to select and record the language input, evaluates the learner performance and facilitates user language output. In this way learners are given more freedom and autonomy in learning and can decide what to learn and how to learn.

Given the wide access to the Internet and a rapid drop in the cost of mobile smartphones and tablet PCs, it makes great sense to develop intelligent CAVL tutors and tools which can be hooked to any webpage. Reading a webpage, the learner can look up the word meaning via a built-in electronic dictionary or a linked web dictionary/concordancer. In this sense, a well-designed and user-friendly electronic dictionary is crucial to the initial process of learning new vocabulary items encountered in the web. It is suggested that the electronic dictionary be equipped with the mouse-click-display-gloss function to shorten considerably the traditional look-up process by which the learner needs to first minimize the webpage, start the electronic dictionary and then go back to the webpage. After obtaining the word meaning and/or the usage, the learner can record the item in
an e-notebook. A more intelligent way to do so is for the learner to use an intelligent tool that can extract the target item and the context (sentence or paragraph) in which the item is embedded. The learner can then obtain more lexical information by editing and managing the word entry in the e-notebook. The next step is to make use of an intelligent tutor which can automatically generate both receptive and productive exercises based on the lexical information (item, definition, context) extracted earlier to help learners consolidate the meaning and form mapping. Finally, another intelligent tutor can provide systematic reviews for learners based on the evaluation of various learning information recorded, such as time of recording the item, complexity of the item, familiarity of the item, etc. All these learning procedures, from initial encounter of new items to a systematic review, can be realized in one powerful and comprehensive dedicated CAVL template or otherwise separately in combinations of different intelligent tutors and tools.

CONCLUSION

We need to combine different types of CAVL applications so that they can be well integrated into a systematic approach to developing learners’ L2 vocabulary competence. This holds true whether in the traditional PC or present mobile-based learning environment. A clear framework for categorizing currently available CAVL applications can help us envisage and promote CAVL development in future. Owing to the current wide access to the Internet and a rapid drop in the cost of mobile smartphones and tablet PCs, it is to learners’ great advantage to develop intelligent CAVL tutors and tools and hook them to any webpage to allow learners to maximize the language learning potential available on the internet. A sound tracking system is an integral part of any good CAVL system. A review of tracking systems shows that CALL researchers have used a variety of technologies for tracking different user actions but empirical data is insufficient to demonstrate their direct contribution to vocabulary learning. Future studies should identify user actions pertinent to necessary vocabulary processing levels and investigate how these selected user actions are linked to vocabulary retention. Since most of the user actions tracked are largely quantitative in nature, it would be meaningful to collect and track more qualitative user actions such as videoed learning sessions and users’ verbalized thoughts while using/interacting with the CAVL applications.

REFERENCES


