Using Portable Technology to Build Student Knowledge of High Frequency Vocabulary: A New Era of CALL

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Although CALL (Computer Assisted Language Learning), has received much emphasis in recent years (Levy & Stockwell, 2006, Ducate & Arnold, 2006, Hanson-Smith, & Rilling, S., 2006, Trinder, 2006, Egbert, 2005, Fotos & Browne, 2004, Chapelle, 2003), one of the biggest challenges facing schools and universities that wish to utilize technology for language learning is the extreme cost involved in setting up and maintaining large CALL laboratories. With the ownership rate among students of cell phones and MP3 players now far surpassing that of computers (Browne et al, 2008, in press), developing software for these popular devices seems a logical solution.

Combining previous work in the area of CALL (Browne 2004a, 2004b), with research on the importance of developing learner knowledge of high frequency vocabulary words (Browne, 2002), and the importance of using graded reading materials with low level EFL learners (Browne, 1996, 1998), the author formed a company (www.lexxica.com) with several of his colleagues to develop and offer a variety of free online English Language Learning software applications for cell phones, iPods and PCs (similar services for learning Chinese and Japanese high frequency vocabulary are planned, but the focus of this article will be on the already available free English language related services). The suite of programs are capable of accurately and efficiently assessing the learner's English lexical size, identifying which English high frequency words still need to be taught, and then teaching these important words via a time-intervalled flashcard system and learning games, focused on developing automaticity of word knowledge, and extensive graded reading and listening materials. After a brief introduction to the rationale for the importance of developing vocabulary size, the free software applications which have been developed to help accomplish this task will be introduced.

The Movement Towards the Teaching of Vocabulary

From the beginning of the study of second language acquisition (SLA), the field has seen many swings, from a focus on grammar acquisition to a focus on learning processes. Traditionally, vocabulary learning and instruction were seen as somehow isolated and separate from the mainstream theories of SLA. With the grammar-translation method, and its focus on the syntax of the sentence, it was thought that once the students learned the grammar of the sentences, they would be able to slot in vocabulary and therefore generate language. With the advent of the Audiolingual method, based on habit-formation, vocabulary was again treated in much the same way. Words were taught as replaceable elements within sentence structures that always were the central focus of language learning. Subsequent research has often attempted to account for SLA by looking at grammatical features in such areas as developmental sequences (Cancino, Rosansky, & Schumann, 1978; Pienemann, 1989), the role of input (Loschky, 1994; Shook, 1994; White, Spada, Lightbown, & Ranta, 1991), as well as the role of instruction (Dulay, & Burt, 1973; Ellis, 1992; Sharwood Smith, 1981; VanPatten, & Cadierno, 1993). From the publication of

Corder's seminal paper in 1967 to Larsen-Freeman writing in 1991 on SLA research, the study of grammar and its acquisition has almost become synonymous with SLA.

Concurrent with these developments in SLA, yet somehow apart, certain scholars began to study the needs of the learners from a lexical perspective. Many of the questions they asked, and the results they found are still relevant today. These questions included how many words a student needed to know, how these words should be sequenced, and what the student needed to know about these words.

One of the first debates centered on the number of words that a student needed to know. This necessarily led to defining what a word is, and what it means to know a word. While this research primarily focused on first language acquisition, there are obvious implications for SLA as well. The central argument was whether it would be possible to increase a learner's vocabulary by the direct instruction of words and their meaning. If estimates of native speakers vocabulary were very large, then explicit instruction would not be feasible, and early research seemed to indicate that this was the case. Studies cited in D'Anna, Zechmeister, & Hall, (1991) suggested a recognition vocabulary of 155,736 – words (Seashore & Eckerson) and over 200,000 words (Hartman) but both studies suffered from methodological problems in defining what a word is. Nagy and Anderson (1984) used six semantic categories to organize lexis from a corpus of high school English and found that students were exposed to 45,000 base words and 88,500 word families. They suggested that teaching children "words one by one, ten by ten, or even hundred by hundred would appear to be an exercise in futility" (p. 328), and that teachers should concentrate on teaching skills and strategies for independent word learning. Later research by Goulden, Nation, & Read, (1990) questioned whether native speakers actually knew these words. By designing tests based on the frequencies of the words, the researchers determined that native speakers' vocabulary averages 17,200 words. This number suggests that the learning burden is not as insurmountable as previously suggested. Other research by D'Anna, et al. (1991) found a similar result of 16,785 words.

Vocabulary Thresholds for Second Language Learners

Although there are more than 250,000 word families in the Oxford English Dictionary, which is considered to be the largest dictionary of English in the world, research in corpus linguistics has shown that a very small number of these words are actually used in daily life. In an excellent overview of vocabulary research to date, Nation (2001), found that the 2000 most frequent words of English cover approximately 81-85% of words that appear in general English texts, and that the top 5000 words covers approximately 95% of such texts.

How many words do second language learners need to know? Several researchers have discovered important vocabulary “thresholds” beyond which, second language learners are able to function more successfully and independently. Laufer (1992) compared vocabulary size and reading comprehension scores and found that a recognition vocabulary of at least 3,000 words, which offers approximately 90% coverage of texts, was the minimum threshold for being able to read unsimplified texts (i.e. where there were more readers than non-readers of the text). Hirsch and Nation (1992) found that 95% coverage level (5000 words) represents another important threshold, and that once this vocabulary size was reached, learners were

able to read and comprehend texts without the help of a teacher or dictionaries. Unfortunately, EFL learners in most countries do not have nearly this vocabulary size. In Japan, for example, studies by Shillaw (1995), and Barrow et al (1999) found that after between 800 and 1200 hours of instruction, Japanese university students had an average vocabulary size of between 1700 and 2300 words, far short of the amount they need to be independent readers and speakers of English.

Assessing a Learners' Vocabulary Size: The Promise of Computer Adaptive Tests

According to Brown (1995) an essential component of any pedagogical program is a needs analysis. Before designing and presenting materials, it is imperative to gather "information to find out how much the students already know and what they still need to learn" (p.35). In order to help students to learn the words they need to learn, the first step then, should be a diagnostic one – identifying each students' vocabulary size, and more importantly, the specific words each of them already knows. Unfortunately, until very recently, the only way to measure a learner's vocabulary size was either to have them check off all the words they knew in a dictionary (quite impractical!), or to make a rough extrapolation from random samplings of different frequency bands. The most widely used of such vocabulary size tests is Nation's (1990) Level's Test. Though the Levels Test has proved to be useful as a research tool, it wasn't designed to be able to identify which specific high frequency words were known or unknown, meaning that test results could not directly inform classroom pedagogy.

In response to this problem the author worked with several other vocabulary and statistics experts to develop a computer adaptive vocabulary size test know as V-Check (www.lexxica.com). The test, which can be taken with a PC or a mobile phone, utilizes IRT (Item Response Theory) and elements of Signal Detection Theory to quickly assess the number of English words known by learners, as well as their depth of knowledge of those words. IRT states that the probability of getting a correct answer to an item depends on the difficulty of the item and the ability of the student. IRT allows us to be able to measure a test-taker's ability by assessing his or her responses to questions (items) of known difficulty. IRT-based tests are uniquely suited for Computer Adaptive Testing (CAT) and have recently been employed by large testing companies such as ETS who use it for the online version of TOEFL. In the case of TOEFL tests, IRT analysis is used to help establish the equivalency of question items used on different forms of the TOEFL test given in various locations.

In our case, we employ IRT in a very different way. With our V-Check vocabulary test and Level Check assessments, IRT is first used to measure and calibrate the difficulty of each vocabulary word (each an item), and to organize a mathematical ogive (an index) of vocabulary items by their rank order of difficulty. From the 20,000 high frequency words we test, any one respondent will typically see no more than 30 actual items during their testing session. Over time, IRT allows us to establish a very precise measure of each item's difficulty for a given population group.

To implement an accurate IRT-based test, widespread sample testing with the desired population is needed before creating the actual test. Among other things, this allows us to create a valid ogive (thousands of vocabulary words that have been organized by rank order of difficulty) for the population. The ogive gives us the ability to both

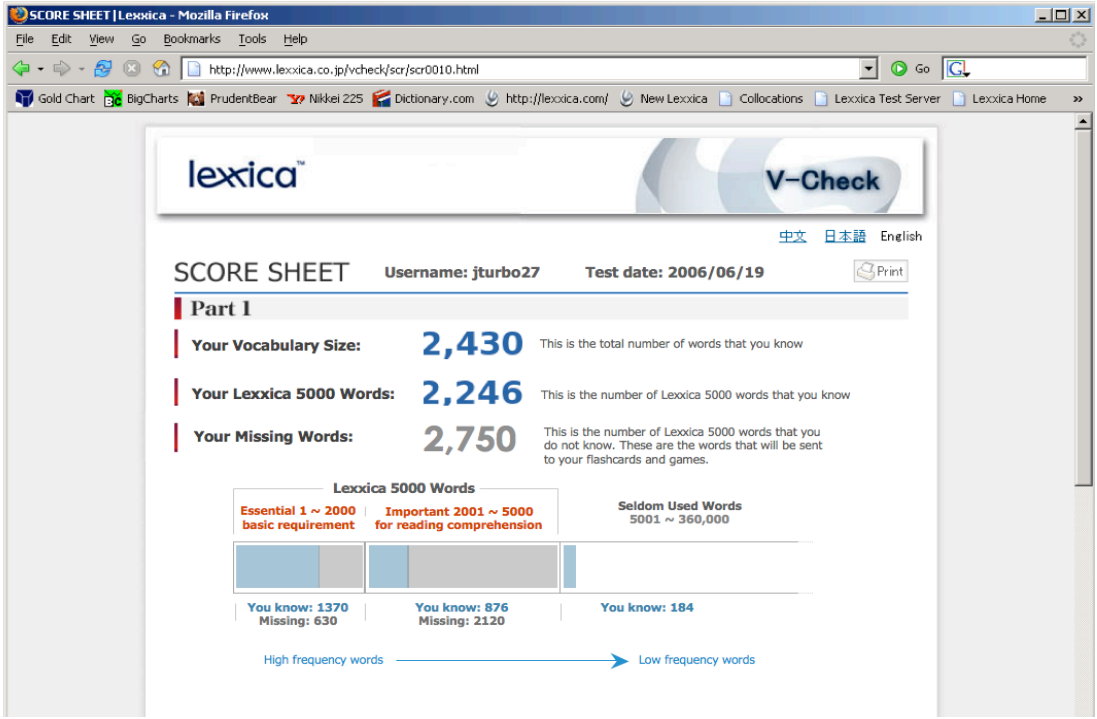
rapidly ascertain each respondent's lexical ability, as well as to statistically predict which specific words are likely known, and not known at each level of ability. In other words, V-Check measures each test-takers' vocabulary ability level with a high degree of probabilistic accuracy and then identifies the words they know, which more importantly, allows us to identify the high frequency words they don't know.

The V-Check test presents respondents with a series of simple questions known as Lexical Decision Tasks. Research has shown that the Lexical Decision Task approach is one of the most highly reliable and statistically valid forms of vocabulary testing. (Meara & Buxton, 1987, Meara, 1992, Harrington, 2006). One benefit of the Lexical Decision Task is that learners are able to respond to far more items in a given amount of time than in traditional types of vocabulary tests. The approach is thus an extremely fast and efficient way of getting a measure of each learner's lexical ability. In the V-Check test, vocabulary words are generated by the computer at varying levels of difficulty and the respondent is asked "Do you know this word?" The respondent gives either a "Yes" or "No" response. After the first item, each next item is then selected to provide the maximum amount of information possible toward establishing an estimate of the student's ability. This process is repeated until a high degree of accuracy is achieved. The amount of time necessary to take the test is variable because the process depends on the responses of the test taker. However, because each item is selected to maximize the information and minimize the error based on an individuals responses, these tests are always more efficient than conventional pencil and paper tests or non-interactive computer tests.

Once a students' level is determined, section 2 of the test then proceeds to ask for definitional knowledge of words selected at and around the respondent's assessed ability level. The definitional questions are presented via a multiple-choice format. The test results indicate the number of real words the respondent can correctly recognize, and the percentage of correct definitions that were given at the maximum assessed level of ability. Initial data seems to indicate that respondents who try to stretch too much on section one of the test (in order to recognize more words than they can independently define) receive a score of lower than 90 percent in section 2. We are theorizing that this is because the words they are being asked to define are above their functional vocabulary proficiency. So far, respondents who are more cautious and precise in their responses on section one, answering "Yes" only to words that they confidently know, are usually able to achieve scores of 90 percent or higher in section 2.

The whole test finishes in 6 to 15 minutes, dependent on the response pattern of the test taker. One of the most unique and useful aspects of the V-Check test is that since the IRT analysis allows us to predict which specific words are already known by the learner, each student who takes the test is able to receive their own personalized list of next most important high frequency words for study.

Figure 1: Screenshot sample V-Check Results Page



As can be seen from figure 1, results with Japanese test-takers has revealed an interesting aspect of EFL word knowledge among Japanese students – they don't tend to learn words in the order of frequency. This particular student score sheet (Figure 1.) is from a first year university student in Japan. It indicates that he knows more than 2400 words, a score not dissimilar to the research results of Shillaw (1995), and Barrow et al (1999), cited earlier in this article. This sample V-Check score sheet also shows a very large gap of 630 missing (unknown) words from among the first 2000 most frequent words of English. While this student recognizes 2430 total words of English, he is missing many of the most frequently used words, which greatly limits his reading comprehension ability. This profile is typical of the thousands of Japanese students who have taken the V-Check test. Research has shown that knowledge of the first 2000 most frequent words is crucial to gaining basic proficiency in English. The first 2000 words provide up to 85% coverage of written texts (Nation, 1990, 2001). For most Japanese students, learning their missing high frequency words will be of critical assistance in helping to achieve independence as learners. Interestingly, the score sheet also points to the fact that the student knows quite a few lower frequency words (more than 870 words in the 2001-5000 frequency band) and another 180 words that are beyond even the 5000 word frequency level.

Why do such vocabulary knowledge gaps occur? Although it is not within the specific scope of this article, research by the author and others (Browne, 1996, 1998, 2002, Kitao and Kitao, 1995, Butler and Iino, 1995, Kikuchi, 2006) have pointed to both the extreme difficulty of reading texts used in high schools and on college entrance exams as well as the undue emphasis in general that Japan's secondary education system's places on teaching English in order to pass college entrance exams (rather than for purposes of communication) as contributing factors.

As was mentioned previously, V-Check is unique among vocabulary tests in that it not only estimates a learner's vocabulary size and identifies the gaps in their knowledge, but it is also able to make accurate predictions about which specific high frequency words are known and unknown, making it a useful starting point for developing an individualized vocabulary learning program.

Direct Study of Vocabulary Through Flashcards and Games

Once a person's missing, unknown, or unclear high frequency words have been identified, how are they learned? Research going back more than a hundred years (Ebbinghaus, 1885, Pimsleur, 1967, Leitner, 1972, Mondria, 1994), has shown that learning new words via a time-intervalled review of flashcards is one of the most efficient ways to quickly increase one's vocabulary size and to move knowledge of these words from short term to long term memory. In their "hand computer" studies, both Leitner (1972) and Mondria (1994) devised elaborate spaced repetition systems for quickly learning new words. Use of personal computers was not yet widespread at the time they published their studies, so they recommended the use of packs of vocabulary cards and a shoebox divided into multiple slots, with each slot representing a different time interval for review. Although the results of these studies were very promising, keeping track of the correct time intervals for the review of hundreds of physical cards proved to be too cumbersome and demanding for most learners (and teachers, too). Our fully automated electronic learning applications eliminate the weaknesses inherent in working with paper cards and shoeboxes. We have developed a fully personalized spaced repetition 'Word Engine' which functions autonomously for each individual student. The Word Engine utilizes multiple learning game applications and electronic flashcards, keeping track of every response and interaction regardless of the type of electronic interface (PC or mobile) that the user prefers. The Word Engine selects the new target words and phrases for each learner after checking their section 1 and section 2 V-Check scores, or (in the cases where no score sheet is issued) their Level Check assessment. The Word Engine then automatically prioritizes each learner's flashcards and then, through the use of invisible time tags, is able to recycle them via a time-intervalled process similar to that outlined by Mondria (1994) and deliver learners the words they need to be reviewed at exactly the right time intervals.

Figure 2. Two screenshots of an Electronic Flashcard for the target word “substitute”.

Figure 2 shows the front and reverse sides of an electronic flashcard. The front side of the card reveals the target word “substitute” along with the question “Do you know this word?”. The learner tries to recall the definition, and then checks if they were right or not by clicking the “Check It” button. If they were correct, and they reply “Yes”, the word is automatically retired until the spaced repetition timer calls for it to once again be displayed. If the user did not properly know it, and they replied “No”, the word will return to the first time interval slot, and wait its turn to start the process again.

Information appearing on the reverse side of each flashcard is adjustable by the user including the following options.

- Definitions in English (including different “senses” whenever a word has multiple meanings)
- Definitions in the learner’s first language
- Part of speech
- Sound files with native speaker pronunciations of the words
- Frequent collocations for each target word (based on corpus analysis)
- Sample sentences

At this time the Word Engine is capable of testing knowledge of up to 20,000 words, and our database supports learners with the first 5000 most frequent words of general

English as well as 3000 additional special purpose words that are specific to academic testing purposes. For example we have words that are infrequent in general English but are highly frequent on TOEFL, TOEIC, and private university entrance exams.

Another possible problem with vocabulary flashcards is how to sustain learner motivation. Although it is true that flashcards are a very efficient way to learn new words, using them can quickly become boring if they are the sole method of doing vocabulary review. There is a rich tradition in the ESL/EFL classroom of using games with a communicative purpose in the ESL/EFL classroom to increase and maintain learner motivation (Wright et al 1984, Uberman, 1998, Ersoz, 2000) as well as lower the learner's affective filter (Dulay et al 1982, Krashen 1985, Asher, 1965, 1977). This research led us to create several interactive vocabulary learning games to develop automaticity (discussed below). The games are fully integrated with our spaced repetition system such that whether a learner reviews new target words with the flashcards or the games, whenever they correctly recognize the meaning of a word, it will be automatically forwarded to the next stage of the spaced repetition process.

Vocabulary Size and Automaticity

Although there is a growing body of research which has established a relationship between vocabulary size and reading ability (Laufer, 1992, Nation, 1990, Davis, 1968, Anderson and Freebody, 1981, Beck et al. 1982), work done by Daneman (1988) suggests that simply increasing a learner's vocabulary size will not be sufficient since reading comprehension depends not only on the number of words a learner knows, but also on the speed with which they are able to recall each of the word meanings they have stored in their memory. Eskey (1988) argues that the rapid and accurate decoding of language is extremely important to any kind of reading and especially important for second-language readers. Earlier work by LaBerge and Samuels (1974) also points out that fluent readers tend to be able to automatically recognize most of the words they read. In a discussion of the various processes involved in reading comprehension, Abdullah (1993), in a concise summary of research on lexical automaticity, argues that it appears humans have a finite amount of processing ability and that the automaticity of lexical access can free up cognitive processing capacity which can be devoted to the comprehension of text. In other words, fast decoders of language will have a better chance to be a good reader.

Figure 3: Screenshots of the Sight-Words and Sound-Bubbles Vocabulary Games

The two games shown in Figure 3, Sight-Words and Sound-Bubbles, are based on the idea of developing automaticity of word knowledge. In Sight Words, learners are delivered unknown (or not fully learned) high frequency words from the Word Engine's spaced repetition system, and are asked to quickly match the word to the correct response (responses appear in the user's native language or in the target language based on user's settings). Points are awarded to the learner/player based on the speed of identification. In Sound-Bubbles, the learner first clicks on a bubble to hear a word pronounced. The player then matches a correct response to each sound bubble. Initial response to these games has been very encouraging.

Indirect Development of Vocabulary Size Through Reading and Listening

Extensive reading of graded reading materials has been widely used as a way to increase vocabulary size and to improve both motivation and overall ability in English (Day and Bamford, 1998. Susser and Rob, 1990). With clear evidence that EFL reading materials are far too hard for learners in Japan, (Browne , 1996,1998, 2002, Kitao and Kitao, 1995, Butler and Iino, 1995, Kikuchi, 2006), use of graded reading materials has been strongly promoted in recent years in Japan through organizations

such as SSS (http://www.seg.co.jp/sss/). Until now, most attempts to conduct extensive reading programs have made use of physical books, usually through the creation of graded libraries from which students can borrow books to read at home.

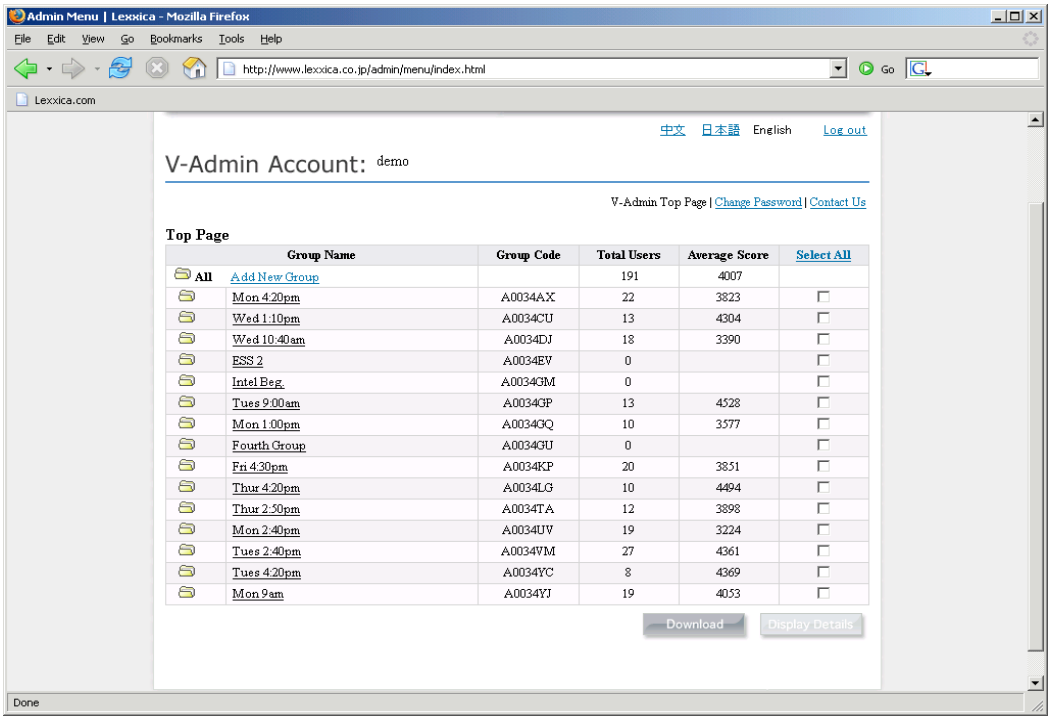
With the amazing growth of the e-book market in English speaking countries (and more recently in Japan), and a virtual 100% cell phone ownership rate by Japanese college students (Browne et al, 2008), we decided to offer graded reading materials that could be accessed online. Although we had first thought to work with major publishers to have them offer electronic versions of their existing books online, the extremely slow process of working out rights issues led us to realize the only way to do this would be to create our own original graded materials. Rather than trying to duplicate the excellent work done by the major publishing houses in creating book-length graded readers, we have opted instead for creating materials on current topics of much shorter length (approximately 1000-1200 words). We are currently on schedule to be able to offer 100 stories at 4 levels of simplification (1000, 2000, 3000 and unsimplified) in 10 different categories that include topics such as Current Movies, Famous Performers, Music, Sports and Food.

Although there has not yet been much published research related on the specific benefits of using graded listening materials, we strongly felt that offering learners recorded versions for all of our graded reading content would be helpful in developing their listening skills. These audio files can be listened to via a web browser, or downloaded into any MP3 player such as an iPod. We are also working to develop applications to teach the most frequent English spoken phrases as well as additional special purpose vocabulary lists designed to help prepare people for success in different careers.

V-Admin: Keeping Track of It All

Although all of the software we have developed has been designed for individual learners to self-access in an easy and intuitive way, from the very beginning we realized that free cell phone software for measuring and tracking vocabulary development would also be of potential interest to teachers and CALL administrators. To this end, we created the V-Admin administration program.

Figure 4: Screenshot of V-Admin (Beta version)



As can be seen in Screenshot 4, the current version of the V-Admin program allows a teacher to track student scores on the V-Check vocabulary test. In order for the program to work, teachers must first log in and create their free account. They can then create as many classes as they want. Each time they create a class, a code is generated which the teacher gives to their students. When students log in, they are asked if they have a class code. If they enter the code, the student's V-Check scores will be automatically reported to the teacher. The V-Admin is now in the process of being upgraded so that it can also track student progress on all other programs (such as flashcards, games, graded reading materials) as well as generate individualized quizzes based on the words a learner is working with.

After several years of research, software development, and extensive testing, our programs have only recently become available for online use by students (and teachers) around the world. The positive reactions and support we have received thus far from learners, teachers, and fellow researchers has been extremely promising. With many schools not able to afford adequate CALL facilities to accommodate all their students, we are hoping that the fact that all of our software can be used on cell phones will help teachers and schools to be able to utilize this modality as a new type of self-access center.

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