Story-based CALL for Japanese Kanji Characters: A Study on Student Learning Motivation

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We investigated the feasibility and effectiveness of implementing a novel, story-based computer-assisted language learning (CALL) system for students learning Japanese kanji characters. In contrast to traditional kanji instruction methods, which rely most heavily on rote learning, our story-based CALL system focuses on mnemonic stories (following Heisig, 1986) and allows the user to create and manage mnemonic stories. System features include a multi-modal audio/visual interface, a portable form factor, a flashcard quiz mode, hyperlink navigation among stories, and a story sharing facility. Experimental evaluation results indicate that after using our device for a two-week period, statistically significant and statistically suggestive improvements in six aspects of students' motivation and learning strategies for learning kanji increased, as measured by the Motivated Strategies for Learning Questionnaire.

The writing system for the Japanese language has been described as one of the most complicated in the world (Coulmas, 1989; Bullock, 1999; Joyce, 2005). It follows that students of Japanese as a Second Language (JSL) may be expected to encounter great difficulty in learning written Japanese, in particular the kanji characters. To assist JSL students with the difficult task of learning kanji, we developed a novel mobile computer system based on a "mnemonic-stories kanji learning strategy from Heisig's kanji textbook (Heisig, 1986). We believe that our computer-assisted language learning (CALL) system can positively affect student motivation for the kanji learning task, and therefore increase students' long-term success in learning kanji. In this paper, we first review the background of the Japanese writing system, then examine Heisig's

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mnemonic method and present our novel story-based kanji CALL system. Finally we present and discuss experimental results showing effect of our system on student kanji learning motivation.

Background

One of the greatest challenges (Gamage, 2003b) for JSL students is learning the large number of *kanji*, the logographic characters used in Japanese and originating from the Chinese writing system. Basic literacy in Japanese requires learning at least 2,000 kanji characters, which have varied and complex visual forms. For JSL students with backgrounds in alphabetic script languages, where less than 10^2 written characters need be learned, the task of learning more than 10^3 Japanese kanji represents an order of magnitude increase in the number of characters to learn. Not only does this inherently place a great burden any student's memory; it also confounds the JSL student with a large-scale character memorization task which may be unlike any other learning or memorization task from the student's past experience (Heisig, 1986; Richardson, in press).

Despite the challenging and unique nature of a large-scale character learning task, traditional instruction techniques for Japanese kanji frequently emphasize rote learning strategies (Shimizu & Green, 2002). Shimizu and Green (2002) offer the explanation that native Japanese teachers may tend to use teaching methods based on their own experiences learning kanji – which likely involved rote learning over many years as children in grade school. However, learning methods used by native Japanese children are not necessarily the best methods to be used by adult JSL students (Gamage 2003a). For example, Heisig (personal communication, April 3 2007), frames the JSL kanji-learning question as "how do you learn kanji, if you've never seen one before? The native Japanese teacher, exposed to kanji since childhood, has a different mindset than the novice JSL learner, who may never have seen kanji before. This is not to say that traditional techniques are without merit; instead, we simply would like to acknowledge that alternative learning methods may be equally or more effective for JSL students. The difficulty with rote learning of kanji is the sheer number of characters which must be learned, kept in memory, and not confused with one another. Thus, the effectiveness of rote memorization strategies is unclear (Gamage, 2003b), and rote memorization can, over longer periods, easily lead to students forgetting or confusing old characters as they memorize new ones (Richardson, 1998).

Mnemonic Stories for Learning Kanji

A promising alternative to rote learning is the use of mnemonic strategies, where additional mnemonic information is used by the learner to encode and recall the kanji shapes and their meanings. Although mnemonic strategies have been proposed and evaluated for JSL learners (e.g. Matsunaga, 2003; Kuo & Hopper, 2004), most JSL mnemonic strategies are small-scale, ad-hoc, and applied inconsistently to only to a few characters – certainly less than the 2,000 needed for literacy. If a mnemonic strategy is to benefit the JSL student, it must be systematic and consistently applicable to the large number of characters the student must learn (Richardson, in press).

Heisig's textbook (Heisig, 1986) is an example – and to our knowledge, currently the only such example – of a systematic, large-scale mnemonic story method applicable to all of the 2,000 daily-use kanji needed for literacy. The remainder of this section is devoted to a brief explanation of Heisig's textbook method, after which we describe our novel story-based kanji CALL system based on the method.

Heisig's textbook aims to teach beginning JSL students two things: the written forms and meanings of kanji. It intentionally omits any discussion of pronunciation or compound-kanji vocabulary, asserting that these issues are more easily learned *after* the student has mastered the writings and meanings of all 2,000 daily-use kanji. This decision to separate orthography and phonology is not without controversy, but is supported at least partially by evidence from Gamage (2003b) that beginning JSL students prefer not to use phonological strategies when learning kanji. (See Richardson (1998) for a more exhaustive justification.)

Heisig's mnemonic story method hinges on two principles. The first principle is an unambiguous identification of every graphical component by means of a keyword or keywords. Every kanji is broken down hierarchically into smaller graphical shapes, and every shape is given one or more keyword names. (Approximately 90% of the 2,000 daily-use kanji can be decomposed into smaller shapes; around 10% cannot be decomposed.) Some smaller graphical shapes may themselves be complete kanji; in this case, the keyword name represents the kanji meaning. Other smaller component shapes may be unable to stand alone by themselves, only appearing as components inside larger kanji; in this case, the English keyword serves primarily as an arbitrary name for the shape and may or may not carry any etymologically-rooted meaning. The importance of this naming scheme is its systematicity and consistency: every graphical shape (of the 2,000 kanji covered in the Heisig's textbook) can be represented by its keyword(s), and conversely, every keyword *uniquely* identifies one and only one graphical shape.

The second principle of Heisig's method is the formation, by the student, of mnemonic stories to memorize the kanji shapes. The consistent decomposition of kanji into smaller shapes, and the unambiguous identification of every graphical shape by means of keywords, allow complex kanji shapes to be represented by their keywords. To remember a complex kanji shape and its meaning, the student is required to form a mnemonic story linking the word for the kanji meaning with the words for the component shapes. Heisig encourages students to create vivid, memorable mnemonic images in their "mind's eye to create a strong mental association between the kanji meaning (expressed as a keyword) and the kanji parts (expressed as keywords).

The ordering of kanji in Heisig's textbook follows an unconventional order. While traditional pedagogy often teaches kanji in the order of their usage frequencies in actual texts, Heisig's textbook orders kanji based on *compositional complexity*. In other words, graphically simple kanji and primitive shapes are learned first (low compositional complexity). Next, kanji based on compositions of these same earlier, simpler, already-learned shapes are learned (medium compositional complexity). Finally, kanji based on compositions of other already-learned compositions are learned (high compositional complexity). This ordering is based on the assumption that the student plans to learn all the writing and meanings of all 2,000 daily-use kanji, thereby making irrelevant an ordering based on kanji usage frequency, since all kanji (in regular daily use) are to be learned anyway (Heisig, 1986). Also, this

simple-to-complex ordering has the benefit of immediately contextualizing newly-learned complex kanji shapes in terms of already-learned simpler shapes (Richardson, 1998).

Story-based Kanji CALL system

Because of its unique aspects of scalability and consistency over all 2,000 kanji needed for literacy, Heisig's strategy seems a good candidate for a story-based CALL system to assist JSL students in learning kanji. The large number of mnemonic stories that the student creates could lend itself to effective management with a computerized system. One of our research questions, then, was to investigate the feasibility of designing and implementing a novel kanji CALL system based on Heisig's pedagogy, requiring a large number of user-created mnemonic stories.

Existing kanji CALL systems are typically PC-based or web-based (e.g. Li, 1996; Komori & Zimmerman, 2001; Houser, Yokoi, & Yasusa, 2002; Hsu & Gao, 2002). Recently, however, increasing mobile computing power and better mobile user interfaces have made it feasible to implement personal CALL systems on mobile devices. This is the approach we have chosen for our kanji CALL system. Mobile devices offer the benefit of allowing anytime, anywhere learning without tethering the user to a specific location.

Our story-based CALL system is designed to allow the student to input, output, manage, and share mnemonic stories using the kanji keywords from Heisig's textbook. It is important that the creation and input of large numbers of stories be as easy as possible given the constraints of a mobile device. For this reason, we decided to represent stories with the audio modality: students record mnemonic stories by speaking them into our mobile device, and review mnemonic stories by listening to spoken audio.

The overall design of our mobile, story-based kanji CALL system is shown in Figure 1. The student's main task when using the device is to record and review mnemonic stories to remember complex kanji shapes and meanings. The left-side of the screen displays a list of keyword meanings for 1,000 different kanji; the data is adapted from and follows the same order as Heisig (1986). (The device can contain up to 10,000 kanji entries, but we only prepared data for 1,000 kanji.) A cursor highlights the currently selected entry; the cursor can be moved with the device's mini-joystick control. The right-hand side of the screen displays the written form of the currently selected kanji meaning keyword. Beneath the kanji image is a list of the names of the smaller parts (other kanji or primitives) that comprise the current kanji. The student's task is to memorize the kanji meaning - displayed as a keyword on the left - and its written shape - displayed as a decomposed list of part-name keywords on the right. For this, the student must form a vivid mnemonic story, using their imagination, that links together the meaning and part-name keywords. After inventing a sufficiently memorable mnemonic story, the student presses the "record button on the device and speaks their mnemonic story into the device's microphone, pressing the "stop button to stop recording. After recording a mnemonic story for a kanji in this manner, the color of the entry in the list changes from red to green, to signify the student's learning progress. Once recorded, the mnemonic story for any kanji can be played back by selecting that kanji's meaning keyword in the list and pressing the "play button on the device.

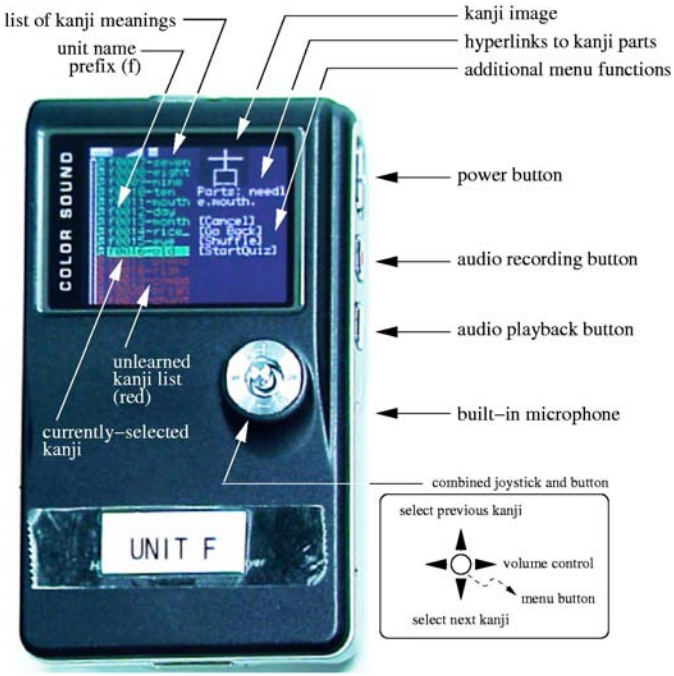

Figure 1. Implementation of a mobile CALL device for learning kanji based on mnemonic stories.

The list of the part names comprising a particular kanji (located in the right-hand side of the display) contains entries which are clickable hyperlinks. This allows quick navigation from a complex kanji (and its mnemonic story) to its related comprising kanji parts (and their mnemonic stories).

An options menu in the lower-right of the display allows additional functions of list shuffling and a flashcard quiz mode. Also, by means of an upload/download function, mnemonic stories from one device can be copied and shared onto another device. Mnemonic stories from a particular device that are uploaded to a different device are prefixed with a single-letter identifier to keep mnemonic stories from different devices distinct.

Student Motivation and Kanji Learning

Earlier research (Van Aacken, 1999; Komori & Zimmerman, 2001) investigated possible benefits of CALL for kanji learning. In particular, CALL has potential benefits for student motivation (Van Aacken, 1999). Student motivation is important because motivation and self-beliefs affect student learning performance (Kondo-Brown, 2006; Mori, Sato, & Shimizu, 2007).

Therefore, to evaluate our system, we decided to test the effect of our system on beginning kanji students' motivation. We did not test the effect of our system on students learning results (i.e. number of kanji learned). The reason for this decision was the short timeframe of our experiment, two weeks. We felt that during this short time frame, it would not be very meaningful to measure the effect of our system on students' learning results, because learning over a two-week period is likely to exercise short-term memory, while the real challenge in learning kanji is facilitating long-term memory of large numbers of kanji. On the other hand, measuring the motivational change over a two week period would be, we felt, a meaningful result. If our system could improve student motivation for learning kanji, then students' chances for success in long-term kanji study would be increased.

Questionnaires are typically used to measure student motivation; such questionnaires may be designed for one particular study (e.g. Hitosugi & Day, 2004), or may be standardized questionnaires, such as the Attitude/Motivation Test Battery (Gardner, 1985; used by e.g. Apple, 2005) or the Motivated Strategies for Learning Questionnaire (Pintrich, Smith, Garcia & McKeachie, 1991; used by e.g. Chang, 2005). One advantage of standardized questionnaires is that they have been validated with techniques such as factor analysis (Pintrich & De Groot, 1990; Pintrich et al, 1991). For our study we chose to use a modified version of the MSLQ.

Methodology

The research questions we wanted to investigate were:

1. Is it feasible to design and implement a mobile kanji CALL system based on story mnemonics as used in Heisig's (1986) textbook?
2. Does such a story-based CALL system positively affect student motivation?
3. What are the strengths and weaknesses of the device in actual use by students?

To investigate these questions, we conducted an experiment as described below.

Participants

Eight unpaid volunteers (four male, four female) were recruited by means of flyers posted around the Nagoya University campus. All subjects spoke English well (a requirement because of the English-language keywords used by our system). Also, all subjects self-reported that their kanji knowledge was at a very beginning level, and that they were interested in trying out a new mobile device for kanji learning.

Instruments

Since we aimed to measure student motivation, we used a modified version of the MSLQ (Pintrich *et al*,, 1991). The original MSLQ measures student motivation and learning strategies in 15 different subscales. Each subscale, in turn, consists of several questions measuring one particular factor concerning the student's motivation or learning strategies. Each question states a particular learning activity or belief, and subjects must answer with the degree of applicability of that item to the themselves. All responses are given on a Likert-style scale

from 1 to 7 (1=not true for me, 7=very true for me). To compute the MSLQ score for a particular subscale, the mean of the values of the subject's responses for that subscale is computed.

Because the MSLQ is designed for use in general learning scenarios, some of its subscales do not apply to the specific scenario of learning kanji. For example, the MSLQ "critical thinking category of questions do not apply to learning kanji, since learning kanji is a memorization and not a critical thinking task. We thus adapted the MSLQ to suit our particular learning domain (other examples of adapted motivational questionnaires can be seen in Marra *et al.*, 2000; Liu, 2007). Phrasing relating to "understanding the content of learning material was either omitted or re-worded to address the kanji memorization task. We discarded three MSLQ subscales as being unadaptable to our kanji learning task: rehearsal, organization, and critical thinking. We retained the following 12 scales: intrinsic motivation, extrinsic motivation, task value, control of learning beliefs, self-efficacy for learning, anxiety of using kanji (modified from "test anxiety), elaboration, meta-cognitive self-regulation, time-management, effort, peer help, and help-seeking. Our adapted MSLQ had a total of 72 questions. Additionally, we designed 2 new subscales (total 7 questions): subscale "knowledge of kanji learning strategy (4 questions), to measure if the students believed that they had an effective kanji learning strategy; and subscale "kanji differentiability (3 questions), to measure if the students believed they could effectively differentiate similar kanji shapes.

Procedure

Subjects were divided into groups of size two or three. During an initial meeting, subjects filled out a demographic questionnaire and responded to our adapted MSLQ. Next, subjects were given our mobile story-based kanji CALL device, and were instructed on the mnemonic story method and usage of our device to record, playback, navigate, and share mnemonic stories. Subjects took the device home with themselves and, over the next two weeks, used the device whenever they had time during their daily routine. Subjects were asked to to learn as many kanji as they wished using the device, by making mnemonic stories. At the end of one week, subjects copied their mnemonic stories from their own device onto the devices of the other subjects in their group, allowing subjects the opportunity to hear other subjects' mnemonic stories. Subjects continued to use the device during their daily routine for the following week. At the end of two weeks, subjects returned the device, again filled out the MSLQ, and answered questions on device usability (both in Likert-scale form and in free-form questions).

Data Analysis

For each student, we computed student motivation before (pre-test) and after using our device (post-test), by calculating the MSLQ scores for each of the subscales we employed (12 adapted MSLQ subscales plus 2 custom subscales). To determine, over all students, if there was a difference in MSLQ subscale scores before and after using our device, we used 14 one-tailed Wilcoxon signed-rank tests, one for each subscale, on the pre-test and post-test scores for all subjects. For all but one of the subscales that we employed, an improvement in motivation would be reflected by higher post-test subscale scores; for one subscale

("anxiety of using kanji), the direction of improvement is reversed, so that an improvement in motivation would be reflected by lower post-test subscale scores. Data analysis was conducted with the R statistical package version 2.5.0 (R Development Core Team, 2007) using the exactRankTests package (Hothorn & Hornik, 2006).

Although it is possible to use paired t-tests for repeated measures to detect a difference between pre-test and post-test measures (e.g. Chang, 2005), in the case of questionnaire responses given on a Likert-style ordinal scale, it is more conservative not to assume equal spacing or normal distribution of ordinal elements, thus suggesting use of the non-parametric Wilcoxon signed-rank test for paired data.

Results

Of the 12 adapted MSLQ subscales and 2 custom subscales we employed, statistically significant differences between pre-test and post-test scores were found for five subscales: anxiety of using kanji ($p<0.01$), knowledge of kanji learning strategy ($p<0.01$), kanji differentiability ($p<0.01$), control of learning beliefs ($p<0.05$), and meta-cognitive self-regulation ($p<0.05$). A statistically suggestive difference at the $p < 0.1$ level was found for one subscale: self-efficacy. Other subscales showed no statistically significant differences between pre-test and post-test scores. Table 1 summarizes the results. Due to the ordinal-scale nature of the questionnaire responses, instead of the mean and standard deviation of the scores, we report the median and 25%-75% Inter-Quartile Range (IQR). Figure 2 graphs the pre-test and post-test median scores for those subscales where a difference was found at $p<0.01$, $p<0.05$, and $p<0.1$ levels.

Additionally, students were asked, in written form, Likert-scale questions (1=not true for me, 7=very true for me) and free-form questions about the device's usability. Table 2 shows the results of the Likert-scale usability questions. Table 3 shows a selection of some of the free-form questions and answers that we found insightful. Responses were transcribed as accurately as possible from hand-written text.

Discussion

Feasibility of implementing story-based kanji CALL system

Regarding our previously-stated research questions, the first question was to investigate the feasibility of implementing a computer system for kanji CALL using Heisig's (1986) pedagogical idea of mnemonic stories. As we were able to successfully implement the device and test it with students, we can affirm the feasibility of a CALL system using mnemonic stories.

Some difficulties, however, arose during the implementation. The major benefit of Heisig's (1986) decomposition and keyword naming of kanji parts is its large degree of systematicity and consistency. The decomposition scheme is applied in the same manner to all 2000 daily-use kanji, allowing unambiguous identification of a graphical shape given its keyword. However, when adapting Heisig's decomposition data for computer use, many minor inconsistencies in word usage had to be corrected. For instance, in the textbook (Heisig, 1986), a graphical part might be named "water drops, but later be referred to as "water or "drops of water. In our CALL system, we either eliminated such inconsistencies by using the

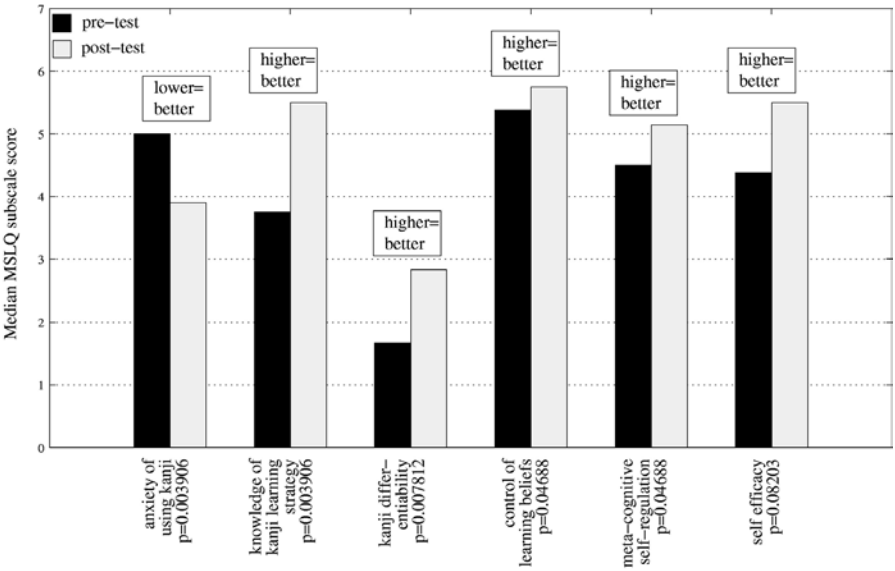

Figure 2. Differences between pre-test and post-test MSLQ subscale scores at $p<0.01$, $p<0.05$, and $p<0.1$ levels

Table 1. Differences between pre-test and post-test MSLQ subscale scores (N=8)

MSLQ Subscale	Pre-test median (IQR)	Post-test median (IQR)	Wilcoxon signed-rank test S value	p
anxiety of using kanji	5.00 (3.00)	3.90 (2.50)	S = 0	p = 0.003906 **
knowledge of kanji learning strategy (custom subscale)	3.75 (1.50)	5.50 (1.56)	S = 0	p = 0.003906 **
kanji differen-tiability (custom subscale)	1.67 (1.17)	2.83 (2.25)	S = 0	p = 0.007812 **
control of learning beliefs	5.38 (0.88)	5.75 (1.38)	S = 3.5	p = 0.04688 *
meta-cognitive self-regulation	4.50 (0.96)	5.14 (1.57)	S = 3.5	p = 0.04688 *
self-efficacy	4.38 (2.65)	5.50 (2.78)	S = 7.5	p = 0.08203
elaboration	4.83 (1.58)	5.50 (1.83)	S = 10.15	p = 0.1719
time management	3.33 (0.75)	3.67 (1.98)	S = 13	p = 0.2617
peer help	2.00 (1.67)	2.33 (1.33)	S = 6	p = 0.4062

MSLQ Subscale	Pre-test median (IQR)	Post-test median (IQR)	Wilcoxon signed-rank test S value	p
intrinsic motivation	4.88 (1.67)	4.75 (1.50)	S = 13	p = 0.4688
extrinsic motivation	3.83 (2.00)	4.00 (2.08)	S = 10.5	p = 0.5312
effort	3.75 (0.94)	4.38 (1.06)	S = 10.5	p = 0.5625
task value	5.25 (1.00)	5.25 (1.50)	S = 12	p = 0.6406
help-seeking	4.83 (1.50)	3.50 (1.83)	S = 20.5	p = 0.8672

Table 2. Likert-scale questionnaire responses regarding device usability.

Question	Median response (IQR)
Using the mobile device to record and playback stories was easy.	7(2)
Using audio to record stories is easier than typing stories on a keyboard.	7(0)
I want my stories to be available in text form so I can read them on-screen.	4.5(4.5)

Table 3. A selection of free-form questionnaire responses regarding device usability. Responses were transcribed as accurately as possible from hand-written text.

	Question	Free-form response
1	Was it difficult for you to imagine (to create) a story for each kanji? If yes, why?	
2		Yes. The way to make stories for different kanji sometimes is quite similar which cause difficulties in remembering new kanji. Sometimes I am fed up with my own stories. Clues for stories are limited.
3		Depending on the kanji, sometimes I needed up to 15 minutes to create a story, sometimes I had a story even before I checked the meaning of the kanji.
4		Yes, after several stories, they started to become more and more difficult. Mostly because some were very similar and had to have different stories. And parts were not closely related, that also made it more difficult.
5		Sometimes, because the "part" did not always suit the story. However, it was useful to learn some primitive helping word.
6		Yes. Because it has to be a story I can remember and the parts of the story should not clash with parts of other stories -> would be confusing
7		Some kanji had parts which for me seemed difficult to find a relation between all the parts and the actual meaning. So the stories turned out to be silly, unrealistic, or hard to remember for me.
8	Please describe your opinion about using our mobile device for recording and playing back stories for learning kanji.	

	Question	Free-form response
9		It's very convenient and easy to record and play back.
10		In general, I found this device very well put together. I think it's a new and interesting way of learning kanjis.
11		I think its a great idea, since mobile devices are very common and can be used anywhere, you can use it without much trouble and without disturbing others.
12		I did not play back so much as I should, because I write the story down in a small notebook before I read them in.
13		Excellent idea. I used it when walking in the street!
14		Helpful if forgot the story. Makes it possible to listen to it anywhere (subway).
15		Having the stories with the signs on the screen seems a lot more appealing to me, than having kanji learning cards in your bag.
16	Please describe what things you liked BEST about our mobile system.	
17		The order of kanjis, the sequence of each kanji facilitated the learning and creating of stories.
18		The organization, very easy to use.
19		The fact that it is mobile. Hence it is possible to use it everywhere, when you waiting for the subway, sitting on a train, or walking in the street.
20		Links between kanji, so you can jump quickly and easily forward and backward.
21		That it is MOBILE. Pictures of characters + links between parts of the characters. Recording.
22		The best thing I like on the device is, the kanjis are arranged in a systematic way, I mean related kanji come one after another, so it is easy to remember & reduce the confusion on same shaped kanjies.
23		It was small and light. It had enough disk space, the microphone and the sound output were good. having the kanji on the screen.
24	Please describe what things you liked LEAST about our mobile system.	
25		1. It doesn't have guideline for reading kanji (I don't know how to read kanji by this mobile system). 2. The order of kanji (I prefer the kanji to be put in the order of necessity)
26		1. I found the quality of images for kanji rather poor. 2. There was no way of learning writing of any kanji.
27		Some of the concepts were not so clear, or not so common. I had to use a dictionary and that slowed me down a little.
29		Small screen!
30		Layout of screen. Primitive meaning of characters (confusing, sometimes). Layout of screen.
31		It would be better if it has function of how to read the kanji.

	Question	Free-form response
32		The text on the screen looked crappy. It was slow for loading the info of a kanji when selecting. I don't like to hear my own voice in the story. usually nobody likes that... the kanji didn't have a logical order (but depending on older kanji learned which is probably meant to be like that in the book/ program)
33	Do you feel that our mobile system is missing any features needed for learning kanji? If so, please describe these missing features.	
34		How to pronounce kanji
35		I think design of device could be improved significantly. I.e., the pushing button can be made more as in i-Pods and the size of the text can be a little bit bigger.
36		It would be helpful if it was clearer to know whenever a primary meaning was there or only a helping word. sometimes difficult to distinguish this.
37		Maybe is good idea to show how kanjis are written (I mean: how to write kanji, move of the pencil)
38		Touchpad screen(?) -> to write kanji by myself. Kun and On meaning (audio and written output). Quiz -> Store function or list of kanjis that I could not remember.
39		Reading system.
40		I guess in the learning system, this program is not really planned. But I was really missing: order of strokes. Many kanji look quite the same but have different stroke order. I often think about that. Pronunciation: when the person has learned the meaning of the kanji and the writing, he/she should be able to activate a part which explains the different meanings and readings.
41	Please include any additional comments here (e.g. your comments on stories, kanji, our mobile device, etc.)	
42		I think the way of learning kanji introduced in the book and used in the device requires quite much time until success. You learn the parts very fast and the meanings. But just after that you are supposed to learn the readings and combinations? I think in long term there might be a better success in this system. But school classes (especially classes of exchange students in Japan, etc) focus on having success in a short time (as these students leave after one or two semesters) and therefore, this learning seems not to fit the needs of such courses. I guess the program fits best for people learning alone and not needing a short-term success.

same keyword everywhere, or allowed the inconsistency by registering multiple keywords to one kanji shape. Note, however, that a given keyword (e.g. "water drops, or "water, or "drops of water) still unambiguously identifies only one kanji shape; therefore, mnemonic stories using a set of keywords also unambiguously identify the comprising kanji shapes. It is the reverse direction, from kanji shape to keyword, which may be ambiguous.

The issue just described refers to what are likely merely oversights in Heisig's textbook: a single graphical shape is *unintentionally* given multiple keyword names through a slight carelessness in phrasing. Another directly-related difficulty is the *intentional* assignment of multiple keyword names to one kanji shape. As mentioned earlier, in Heisig's textbook, a graphical kanji shape may be able to stand by itself as a complete kanji shape, as well as being used as a smaller component in more complex kanji. In such a case, Heisig often assigns two keyword names: one keyword for the meaning of the kanji by itself, and a separate but usually related keyword for the meaning of the kanji shape when it appears embedded in a more complex kanji (Heisig calls this second case the "primitive meaning of the kanji shape). The difficulty is that when multiple keyword names – say, *aaa* and *aab* – are given to a kanji shape, later occurrences of that kanji shape embedded inside of more complex kanji require the student to make a *choice* as to which of the multiple keyword names (*aaa* or *aab*) the student wishes to use in forming a mnemonic story. Heisig's textbook is peppered with phrases of the sort "for this kanji, make a mnemonic story using the two keywords *aaa* and *bbb*. Alternatively, instead of *aaa*, you can use the two keywords *aab* and *bbb*.

This occasionally-occurring freedom, to choose which of multiple keywords should be used in making a mnemonic story, would have complicated our interface design, particularly given the small-screen constraints of a mobile device. To allow the user complete freedom, every keyword, for which there is a choice of possible keywords, would need to be alterable by means of a menu or some selection mechanism. Available space on our mobile device's screen was already extremely limited, so there was no way to implement such a keyword-choice feature without requiring complex nested menus. Furthermore, we did not wish to confuse our experimental subjects, who would be using our device for the first time, by *requiring* them to choose among different possible keywords. Therefore, for every complex kanji composition for which Heisig (1986) presents the student with a *choice* of keywords for the smaller parts, we arbitrarily chose only *one* of the keywords to display for each smaller part. In this manner, when our device displays a complex kanji and its decomposition into smaller parts, each smaller part was named with only one keyword name (and not with multiple possible keyword names). Although we believe that our simplification was the correct decision from a user-interface perspective, one subject did complain in some cases about our choice of which of the multiple possible keywords to display, and instead would have sometimes preferred a different choice among the possible keywords. It is a challenge to design a user interface to allow freedom for advanced students to select among multiple keywords to best suit their mnemonic preferences, while not confusing students who prefer simply to be given an unambiguous list of keywords from which to form their mnemonic stories.

Additionally, the input and output modality for the large number of mnemonic stories was an issue that needed consideration. For ease of input and output, we decided to represent mnemonic stories as spoken audio, which also lent itself well to a mobile device and mobile learning scenarios. Two disadvantages are that audio mnemonic stories cannot be searched easily based on their content; neither can they be read on-screen in text form. Nevertheless, we feel that an audio representation is effective. The lack of a search capability for audio mnemonic stories is compensated for by our hyperlink navigation functions, which allow users to easily navigate between complex kanji and their smaller parts. A user can therefore quickly navigate between mnemonic stories based on how those stories (and their associated kanji

graphs) combine to form complex kanji. We believe this renders a search on the mnemonic story contents unnecessary. Furthermore, we also believe that the inability to read kanji mnemonic stories on-screen is not necessary, based on the following logic. We believe the majority of the student's creative effort goes into *creating* the mnemonic story in the first place – a process which Heisig (1986) suggests may take several minutes for difficult kanji. The purpose of recording the mnemonic story is for later review: if the student has forgotten the composition of a complex kanji, their self-created mnemonic story serves as a reminder of how to remember the kanji's composition information. In particular, the user-created mnemonic stories are not "learning content in the traditional sense of material which must be critically read and semantically analyzed or understood for retention. For this reason, the inability to read the content of mnemonic stories on-screen is not a serious drawback.

Effects on student motivation

Our second research question was if our story-based kanji CALL system could positively affect the students' learning process, more specifically, their motivation and learning strategies as measured by pre-test and post-test student scores on our adapted MSLQ. Our adapted MSLQ measured student motivation and learning strategies in 14 subscales, and we found statistically significant differences in five subscales and a statistically suggestive difference in one subscale. Therefore, we conclude that there is evidence that our story-based kanji CALL system positively affects student motivation and learning strategies.

Specifically, at the $p<0.01$ level, the subscales of "anxiety of using kanji, "knowledge of kanji learning strategy, and "kanji differentiability showed statistically significant improvements in the post-test. Regarding the subscales "anxiety of using kanji and "knowledge of kanji learning strategy, we believe that the consistent applicability of the mnemonic story strategy to all of the kanji under study is responsible for the reduction in anxiety. If students are able to internalize a general-purpose mnemonic story strategy for learning any kanji character, their anxiety about kanji will decrease, and their belief in the applicability of their learning strategy will increase. Regarding the subscale "kanji differentiability, we attribute the post-test improvement to the immediate contextualization that our device and the mnemonic story strategy enable. Complex kanji compositions are always expressed, or contextualized, in terms of smaller, already-learned kanji shapes. Our device also supports hyperlinks allowing students to navigate among the contextualized kanji shapes. By learning to decompose and contextualize complex kanji shapes, students become more confident in their own ability to differentiate similar kanji shapes.

At the $p<0.05$ level, the subscales of "control of learning beliefs and "meta-cognitive self-regulation showed statistically significant improvements in the post-test. The MSLQ control of learning beliefs refers to "the belief that outcomes are contingent on one's own effort, in contrast to external factors; MSLQ meta-cognitive self-regulation refers to "the awareness ... and control of cognition ... focused on the control and self-regulation aspects (Pintrich *et al.*, 1991). Again, we believe that the systematic applicability of the mnemonic story strategy gives students an effective way to transform the kanji learning material into a personal mnemonic story form suited to the student's individual memory. The creation of a mnemonic story is a process that the student can control or learn to control, leading to higher control of learning beliefs and self-regulation of one's own learning process.

At the $p<0.1$ level, the subscale of "self-efficacy showed statistically suggestive improvement in the post-test. Self-efficacy refers to "[e]xpectancy for success and "self-appraisal of one's ability to master a task (Pintrich et al, 1991). We believe the positive learning experiences and ability to successfully use the mnemonic story method with our device improved the students' self-perceptions of their ability to learn kanji.

Other subscales did not show statistically significant or statistically suggestive differences in the post-test. We somewhat expected the subscale of "elaboration, which refers to learning strategies that "help the learner integrate and connect new information with prior knowledge (Pintrich *et al.*, 1991), to show improvement post-test. The reason we expected this is that the transformation of the kanji learning task into a mnemonic story building task, where complex kanji are always represented in terms of already-learned kanji parts, provides increased opportunities for elaborational strategies by allowing the student to (a) relate later kanji to earlier kanji and (b) relate the keyword names for graphical kanji parts to their own life knowledge and experience when forming mnemonic stories from the keywords. Furthermore, our device's hyperlink function, allowing students to jump between compositionally related kanji, should have been useful for elaboration. A post-test improvement was observed for the "elaboration subscale, but only at the $p=0.17$ level. The short time frame of our experiment, two weeks, may also be a factor: elaboration, which depends on "prior knowledge, may occur infrequently in a two-week time period because relating new material to prior knowledge may take time. Future studies may be able to investigate more fully the extent to which a mnemonic story CALL system can improve students' elaborational activities when learning kanji.

The remaining subscales for which no statistically significant difference was found were: (1) intrinsic motivation, (2) extrinsic motivation, (3) task value, (4) effort, (5) time management, (6) help-seeking, and (7) peer help. Subscales 1-3 are all "value component[s] (Pintrich *et al.*, 1991) of the MSLQ; the lack of a post-test difference indicates that using our system did not result in an observable change in the students' belief of the value of learning kanji. Because our CALL device and its underlying pedagogy aim to teach students a strategy for remembering kanji characters without the use of or reading of authentic Japanese texts, it is understandable that using our CALL device by itself would not improve students' perception of kanji value. Subscales 4 and 5 relate to "resource management strategies (Pintrich *et al.*, 1991), which our CALL system apparently did not affect. However, because our device is a mobile learning device allowing computer-assisted learning opportunities in mobile situations, it is possible that in a longer experimental study, more effective use of study time or effort might be observed as a result of mobile usage. Subscales 6 and 7 are also resource management strategies, dealing with human resources during learning. Usage of our device did not affect students' reported behavior in interacting with their peers for study purposes, in spite of the group experimental design which allowed students to share mnemonic stories with other students. The currently implemented mobile, story-based kanji CALL system thus seems suited for individual learning and did not result in increased self-reported use of human resources as measured by the MSLQ. It is still an interesting research question to what extent group learning activities help or hinder the kanji learning process when using a mnemonic-story-based CALL system. We are investigating an alternative CALL system implementation which may be more suited for group learning of kanji with mnemonic stories.

To summarize, we found that after using our device, students' belief in their own ability to master kanji increased and their anxiety for learning kanji decreased. We therefore have evidence that using our system had a positive effect on students' learning process and motivation. Learning kanji requires persistence and effort over a long period of time; indeed, it is during the intermediate stages of kanji study when most students lose interest and motivation (Toyoda, 1998 quoted by Gamage, 2003b). Therefore, improving motivation is an important step in supporting students' learning success.

Strengths and weaknesses of CALL system

Our third research question was to investigate the strengths and weaknesses of our implemented mobile, story-based kanji CALL system in actual use.

Earlier we justified our design decision to represent mnemonic stories in audio form for ease of input and output, and addressed the possible shortcomings of such an approach. The results from Table 2 provide some data that reflect on this decision. Table 2 indicates that students did find it easy to use the device and manage mnemonic stories in audio form; however, there was no clear indication from the data of whether or not the students felt they needed text display of their mnemonic stories.

Table 3 shows a selection of some of the free-form questions and responses that seemed interesting. (Line numbers in the following discussion refer to line numbers in Table 3.) Regarding the question in line 1 about the difficulty of inventing a mnemonic story, subjects seemed to encounter difficulties either due to (1) the essentially arbitrary compositional nature of complex kanji, requiring creation of a mnemonic story from essentially arbitrary parts or (2) the increasing memory load as the number of mnemonic stories increased. Nevertheless, it is encouraging to observe that students did recognize the difficulty of and importance of the mnemonic story creation task, and invested sufficient time to form mnemonic stories (e.g. line 3). We also believe that the largely consistent naming scheme of Heisig (1986) makes it at least feasible, though perhaps not easy, to form a large number of mnemonic stories with unambiguous mappings between mnemonic stories and written kanji shapes. A future system feature could be to offer the user some more semantic hints or suggestions for creating a story from the keyword parts, to assist the user in forming a mnemonic story connecting seemingly unrelated keywords.

We argued earlier that the purpose of our mnemonic story recording and playback facility was to serve as a *reminder* to assist students' memory in case they forget a previously created mnemonic story. The reminder nature of the mnemonic story content reduces or eliminates the need for a textual representation of the story. Some support for this idea of a reminder mode of usage can be seen in line 14, where the subject explicitly says the device is helpful in case of a forgotten story.

Subjects generally liked the opportunities for mobile learning that our device enabled (lines 9-15, 19, 21, 23); in particular one subject used the device while walking down the street (line 13). One subject, however, reported first writing stories in a personal paper notebook before inputting them into our device in audio form. There are several possible explanations for this behavior: it may be that this particular user desires to see the mnemonic story content in text form, or that the act of writing helped this subject commit the

story to memory, or simply that the affordances of using paper for organizing story material appealed to this user.

The simple-to-complex ordering of kanji, based on compositional complexity instead of frequency of kanji usage, appealed to some subjects (lines 17, 18, 22) and was in fact the best system feature for some subjects (line 17, 22). Other subjects disliked the ordering (lines 25, 32). Because this kanji learning method requires all graphical kanji parts to be assigned consistent names, simpler kanji must be learned before more complex kanji. Thus, a totally arbitrary re-ordering of the kanji is not possible, though perhaps a block-wise re-ordering would be feasible so that frequent characters would more likely appear earlier than later.

Two subjects reported liking the hyperlinking between compositionally-related kanji (lines 20, 21). Complaints included minor interface issues, as well as requests for stroke order display (lines 26, 37, 40) and information about pronunciation of kanji (lines 25, 31, 34, 38, 39, 40). Because our device implementation is based on Heisig's (1986) pedagogical ideas, which separate orthography from phonology and argue that separation is effective for beginning JSL students, we are cautious about *simultaneous* learning of both mnemonic stories as well as pronunciation information. Heisig (1986) and Richardson (1998, 2001) argue that by fully devoting effort to an effective mnemonic-stories strategy, ignoring at first pronunciation, accelerated learning and retention of all 2,000 daily-use kanji shapes and meanings is possible. Heisig estimates that with *full-time daily study*, in four to six weeks a student can learn and retain the shapes of all 2,000 daily-use kanji: a feat that Heisig himself accomplished in approximately four weeks (Richardson, in press). If these claims of accelerated learning are even partially true, then the possible learning benefits of separating orthography and phonology should not be dismissed out of hand: after successful and hopefully accelerated mastery of orthography, the student could then concentrate all learning effort on phonology, reading authentic texts, and progressing to true literacy (Richardson, 1998).

Perhaps this is best summarized by the insightful observation by one of our experimental subjects, whom we here quote:

> *I think the way of learning kanji introduced in the book and used in the device requires quite much time until success. You learn the parts very fast and the meanings. But just after that you are supposed to learn the readings and combinations? I think in long term there might be a better success in this system. But school classes (especially classes of exchange students in Japan, etc) focus on having success in a short time (as these students leave after one or two semesters) and therefore, this learning seems not to fit the needs of such courses. I guess the program fits best for people learning alone and not needing a short-term success.*

Indeed, as this subject astutely observes, the traditional classroom method of teaching kanji to JSL students is focused on having "success in a short time, where traditional success is defined by quick acquisition of *all* kanji skills (orthography, phonology, meaning, kanji compounds, reading of kanji texts) for a *limited* number of kanji, with the implicit assumption that full literacy of all 2,000 daily-use kanji is not required or perhaps even viewed as impossible. By challenging this assumption, and beginning with the premise that full mastery of at least the daily-use 2,000 kanji is necessary, Heisig's pedagogical method and, we hope, our

story-based kanji CALL system, may be able to help JSL students on the road to literacy at a rate faster than previously thought possible. Naturally, both JSL students and educational institutions are subject to forces and constraints that hamper the idealized scenario of kanji orthography mastery in four weeks: JSL students typically cannot devote full-time daily study to kanji alone, educational institutions may have preferred textbooks or differing philosophies on kanji education, and indeed the mnemonic story method may not be suited to typical classroom environments, instead requiring individual study or a re-thinking of the role of the classroom in learning kanji. It is our hope that our research can provide insights into how mnemonic story-based CALL relates to the overall goal of helping JSL students toward mastery of kanji.

Conclusion

We investigated the feasibility and usefulness of implementing a mnemonic story-based mobile CALL system to help beginning JSL students learn kanji shapes and meanings, using Heisig's (1986) pedagogical method. We decided to represent mnemonic stories as spoken audio, and found that our implementation of the mnemonic stories method was feasible and usable. In our experimental study, after using our story-based CALL system, students' motivation and learning strategies reflected statistically significant and statistically suggestive improvements in six areas, as measured by pre-test and post-test scores on the Motivated Strategies for Learning Questionnaire. User feedback on device usability indicated the audio representation of mnemonic stories was usable and that the mobile form factor was liked.

Future research should investigate how mnemonic-story based CALL systems can co-exist with traditional classroom instruction methods. One question in this regard is how to utilize intermediate JSL students' existing kanji knowledge. If a student has already memorized certain kanji characters without using mnemonic stories or Heisig's shape-to-keyword kanji mapping, how can we tap the student's existing, non-mnemonic knowledge and use it as a foundation for further learning based on mnemonic stories? Additionally, it would be interesting to investigate how and to what extent CALL can support group activities and group learning of kanji through mnemonic stories. Such an understanding could allow mnemonic story CALL methods to be introduced alongside traditional classroom kanji instruction.

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