漢字物語: Design Considerations for a Visual Storytelling Approach to Japanese Language Learning in Augmented Reality

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Abstract

In this paper, we present *Storytelling Kanji* – an interactive, Augmented Reality (AR) application designed to support kanji learning through short vignettes triggered by specially designed kanji flashcards. Here, we present two visual narrative versions of the application and two technological implementations, one using marker-based AR and the other using RFID cards. This paper contributes to research exploring AR as a Multimedia Assisted Language Learning tool and situates lessons learned within the larger body of work on digitally supported Japanese language learning research.

Introduction

The Japanese writing system utilizes three alphabets: katakana, hiragana, and kanji. Research has shown that non-native learners of the Japanese language can be easily overwhelmed when first starting to learn these alphabets, especially kanji (Sara Librenjak et al., 2012; Yoshiko Mori, 1999). The study of kanji involves learning the meaning of each character, as well as several readings. Students may utilize any number of studying methods, including but not limited to flashcards, online quizzes, and writing practice sheets (Heath Rose, 2015). The ubiquity of mobile technologies has led to the development of a plethora of mobile games and apps designed to support kanji learning (e.g. see Caroline Steele, 2012).

In this paper, we explore Augmented Reality (AR) as an interactive storytelling medium to let users experience the meanings of various kanji through narrative vignettes that are attached to custom-made printed kanji cards. AR is an interactive experience in a real-world environment which involves "augmenting" physical spaces or objects with computer-generated information (Helen Papagiannis, 2017). We designed *Storytelling Kanji* as an AR experience to help novice Japanese learners form a strong impression of each kanji's meaning through a narrative experience. AR content is attached to specially designed kanji cards. Using these cards with the app triggers the vignettes, in which individual kanji come alive. In this paper, we present the design history of this application and situate it within the larger body of work on digitally supported Japanese language learning research.

Background

Augmented Reality

Augmented Reality (AR) is an interactive experience of a real-world environment or tangible objects which involves the "augmentation" of these physical spaces or objects by computer-generated perceptual information (Blair MacIntyre et al., 2001). AR differs from Virtual Reality or "VR" in that VR is a computer-generated experience that takes place within a simulated environment. Unlike VR, AR involves a virtual overlay in a real (non-digital) environment. AR can involve multiple sensory modalities, including visual, auditory, haptic (touch/vibration), somatosensory (e.g., pressure, pain, or warmth), and olfactory (smell) (Papagiannis, 2017). Overlaid sensory information can be constructive (i.e. additive to the natural environment) or destructive (i.e. masking of the natural environment) (Andrew Roth, 2014). AR experiences can be supported via a wide array of hardware, including wearable technologies, Head-Mounted Displays (HMD), projectors, and mobile technologies.

Implementing Augmented Reality

Tracking the position of the display, or, alternatively, content in the world, is a key supporting technology that makes augmented reality possible. This allows the content creator to link or affix virtual content to the real world in a meaningful way. According to Zhou et al.'s survey (Feng Zhou et al., 2008) there are three main classes of tracking technology employed in AR systems. These include sensor-based approaches, vision-based approaches, and hybrid approaches. Sensor-based approaches employ the same kind of tracking device as used in virtual reality systems, for instance, electro-magnetic or ultra-sonic trackers. A comprehensive overview is provided by Welch and Foxlin (Greg Welch and Eric Foxlin, 2002). Vision-based approaches include any optical trackers employed by devices like the Oculus Rift or HTC Vive, but also camera-based marker detection tracking. Hybrid approaches employ different kinds of sensors, such as GPS, or inertial sensors.

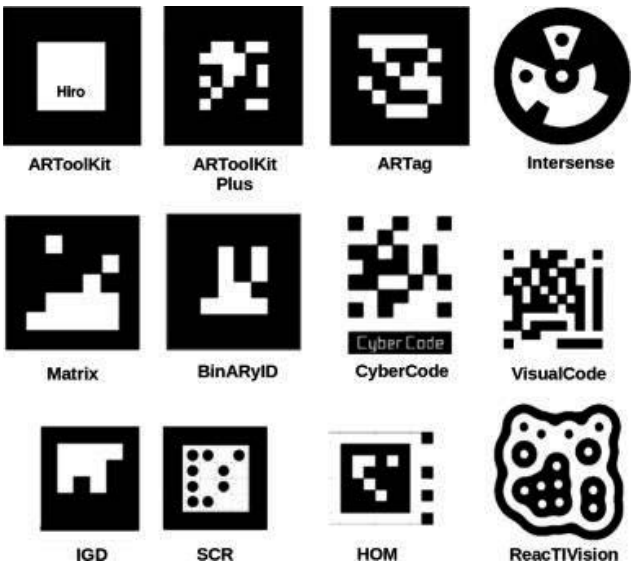


Figure 1. Sample of AR markers

Today, most AR systems employ vision-based tracking. Commonly employed modern approaches to AR tracking can roughly be divided into the following types:

Marker-Based Augmented Reality

This technique is also referred to as image recognition or image-based AR. Historically, this involved the use of fiducial markers (see Figure 1), but advances in computer technologies presently allow us to use any detailed image (e.g., a photograph or mural) as an AR marker by using naturally occurring features (e.g., points, lines) in the image to calculate the pose of the virtual camera (Welch and Foxlin, 2002). When the camera senses the marker, virtual content is triggered by the application.

Marker-less Augmented Reality

This is also referred to as location-based or position-based AR. This type of AR is sometimes achieved using GPS, although such tracking offers only coarse-grain resolution (e.g., on the order of metres) and hence generally cannot provide proper spatial registration between virtual and real objects. Such tracking can also be implemented using other tracking devices or sensors, such as inertial measurement units (e.g., accelerometers and gyroscopes) available in modern mobile devices, for example. This can also be achieved by mounting trackers or sensors in a physical space.

The Japanese Language

The Japanese writing system utilizes three alphabets: katakana, hiragana, and kanji. Katakana and hiragana are both syllabic alphabets. Katakana is often used to write loan words (words from languages other than Japanese), for emphasis, to represent onomatopoeia, for technical and scientific terms, and for foreign names. Hiragana is used for Japanese words that cannot be expressed in kanji and for grammatical inflections, such as particles. Kanji are used to write Japanese names, nouns, and the stems of adjectives and verbs. A sample sentence demonstrating the three alphabets in use is shown in Figure 2.

Figure 2. Sample sentence in Japanese demonstrating the use of the three writing systems: katakana, hiragana, and kanji.

It has been suggested that students should learn approximately 2000 kanji in order to be able to read a newspaper in Japanese (Heath Rose and Lesley Harbon, 2013). As such, non-native learners of the Japanese language can be easily overwhelmed when first starting to learn kanji. The study of kanji involves learning the meaning of each character, as well as several readings (*on yomi* and *kun yomi*). Students may utilize any number of studying methods, including but not limited to flashcards,

online quizzes, and writing practice sheets (Yoshiko Mori et al., 2016).

Multimedia Assisted Japanese Language Learning

The use of digital media applications to support language learning has grown in the past few decades, largely in part due to the ubiquity of personal computers and mobile technologies. In pedagogical research, this is referred to as *Multimedia Assisted Language Learning* – a learning process which is supported by the use of various media such as images, sounds, video, mobile applications, and serious games. In the last decade, the number of mobile applications which have emerged to support language learning has grown exponentially. Today, students learning Japanese can easily download a number of mobile apps and games (many of which are free), to support their studies. Researchers have explored hypermedia (e.g., see Kazuko Nakajima, 1988), games (e.g., see Dallas Nesbitt and AmandaMüller, 2016; Juvane Nunes Marciano et al., 2013; Kristen Stubbs, 2003), interactive educational toys (e.g., see Kamen Kanev et al., 2015; Aya Miyazaki Kiyoshi Tomimatsu, 2009), computer software (Mary Jane C. Samonte et al., 2017), and augmented reality (e.g., see Federico Gelsomini et al., 2016; N. S. Kajita Lin and K. Mase, 2009; Daniel Wagner and Istvan Barakonyi, 2003) as potential tools for motivating learners of Japanese.

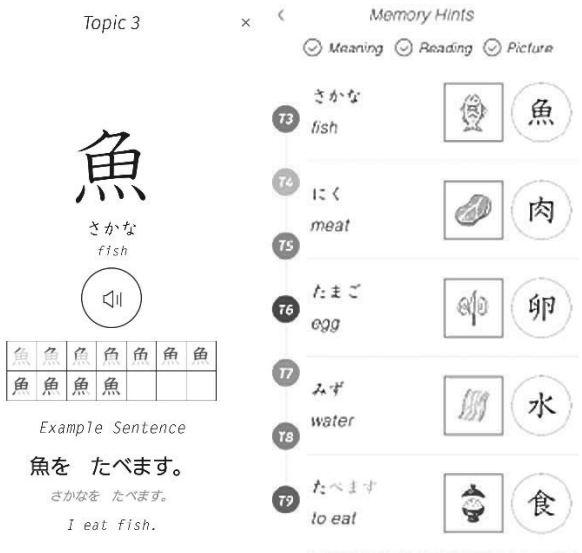


Figure 3. Screenshots from the Kanji Memory Hint app

Librenjak et al. (2012) surveyed 32 multimedia kanji learning tools, including mobile applications (Android and iOS), interactive websites, games (e.g., *My Japanese Coach* for Nintendo DS), and websites that stream Japanese media such as dramas and anime. Some of these tools were specifically focused on kanji acquisition, while others covered various aspects of language learning (e.g., grammar, vocabulary, etc.) and enabled kanji acquisition in a more implicit manner. Of the applications designed specifically for kanji acquisition, most of these resources took the form of digital flash cards or interactive quizzes (Librenjak et al., 2012).

One of the more sophisticated free mobile applications currently available is *Kanji Memory Hint,* which was released for Android and iOS in 2016 by The Japan Foundation Japanese-Language Institute, Kansai (see Figure 3). The application features pictures, sound, animations, kanji, stroke order and sample sentences to help students remember the kanji. The application also includes matching games, information about the writing system, and a kanji table that allows users to tap each kanji to hear how a kanji word is pronounced.

One of the oldest examples of multimedia assisted language learning to support Japanese involved the use of hypermedia (Nakajima, 1988). Nakajima used Apple's Hypercard (a multimedia graphical user interface) to develop a tutorial program that used animations and voice digitizing to achieve an interactive, self-driven learning application (Nakajima, 1988).

A number of serious games have been developed to support Japanese language learning (e.g., see Nesbitt & Müller, 2016; Marciano et al., 2013; Stubbs, 2003). For example, Nesbitt & Müller developed and evaluated a serious game to explore gamified kanji writing, kanji selection, and kanji listening/reading (2016). The authors note, for games to successfully support new learners, they must support the three Cs – they must effectively teach the *concept* of the alphabet, the structure of the *characters* (including phonology, semantic, and visual information), and they must provide a *context* for the student to apply this knowledge. Since kanji learning is largely a task of memorization, being able to use new characters quickly and in context is linked directly to student success.

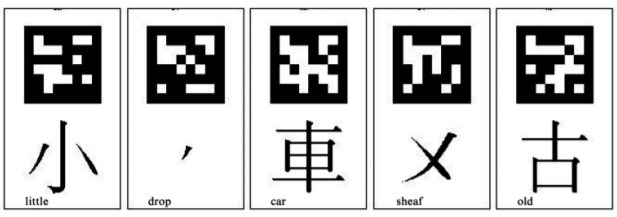


Figure 4. Sample Kanji AR cards from Lin et al. (2009)

One of the earliest applications of AR to learn kanji was developed by Wagner and Barakonyi (2003) – a two-player kanji matching game supported by PDAs in which opponents take turns trying to match ten kanji cards to vocabulary. Gelsomini et al. (2017) propose an educational framework involving tangible AR – the use of physical objects and AR technology to support kanji learning through touch.

Lin et al. (2009) evaluated a collaborative tabletop AR game for two players using marker-based AR to track participant selections of kanji components or radicals (cards shown in Figure 4). If participants placed radicals on the table that could be combined to make a kanji, the system would then prompt participants to collaborative create a short story (drawn or written on a tablet) that would help them remember the kanji's meaning. The design of the application was motivated by the Heisig method (James W. Heisig, 2007).

Motivation

Non-native learners of the Japanese language can be easily overwhelmed when first starting to learn kanji. The study of kanji involves learning the meaning of each character, as well as several readings. Our motivation is to explore the effectiveness of an Augmented Reality kanji learning application for novice Japanese language learners. Potential to combine tangible cards with animations to help learners internalize the meanings of various N5 and N4 kanji characters (Japan Foundation, 2019).

The majority of mobile applications surveyed focus on the development of matching or memory style games that track and score learning (Samonte et al., 2016). We hypothesize that the prevalence of these kinds of applications is not only due to the ease with which this type of quiz algorithm is developed, but that it has also emerged as a digitization of common analogue studying techniques (e.g., the use of flash cards). However, this style of learning game runs contrary to theories on effective game-based learning (James Paul Gee, 2007), which suggests that pedagogical tasks in games and multimedia applications need to move beyond "carrot and stick" approaches to find ways to help learners integrate and use their knowledge in new ways. Although many of the aforementioned mobile games and applications leverage the affordances of interactive technologies (e.g., animation and "gamification"), there are few that effectively leverage effective game-based learning strategies to present content in new and exciting ways.

Our application design is motivated by the visual storytelling affordances of AR technology. Although not a game, its design does not place emphasis on scoring or memorization, nor does it put the player under any constraints during its use. It is not an evaluative technology – rather, it is an exploratory AR narrative designed to provide users with an engaging, memorable, and novel experience interacting with kanji. In the following sections, we present two narrative designs and two hardware implementations of the Storytelling Kanji project.

The Application

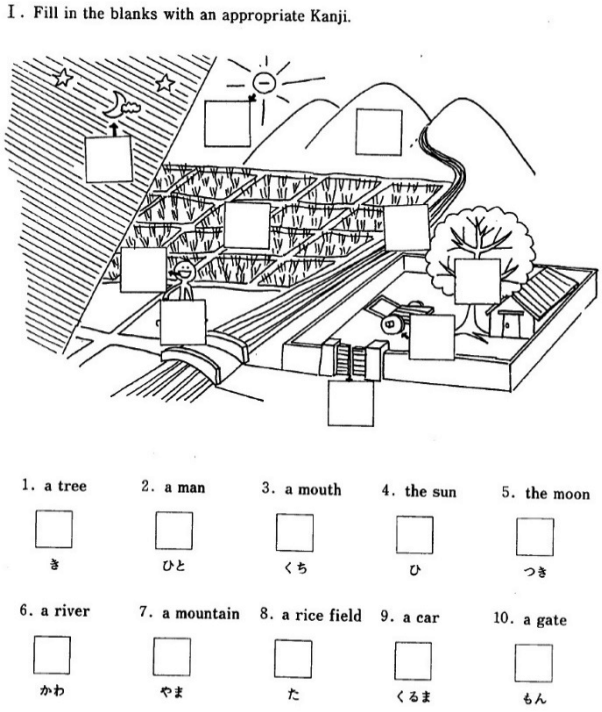


Figure 5. A page from the Basic Kanji Book vol 1 (Chieko Kano et al., 1989).

Here, we present the visual narrative designs of the Storytelling Kanji AR application. Librenjak et al. (2012) suggest that a story-based approach to kanji can produce meaningful relationships between kanji and their meanings for novice learners. The visual design of the application was inspired by the ways in which different learning aids attempt to create meaning through imagery. This is, of course, much easier to do with the first sets of kanji that are introduced to students as they tend to contain few strokes and more closely (visually) resemble their meaning. Paxton and Svetanant note that pictographic kanji are typically

easier to remember than non-pictographic kanji (Simon Paxton and Chavalin Svetanant, 2014).

The application uses kanji cards (shown in Figure 6). When used with the application, the cards trigger animations that replace the modern kanji with a picture revealing its meaning. We explored two visual narrative designs: *Ami's Life in Japan*, and *Kanji as Storytellers.* Our design was informed by Shoukry et al.'s Pre-MEGA framework (Laila Shoukry et al., 2015), which presents detailed heuristics for the evaluation of mobile pedagogical technologies. The heuristics that informed the design of this application and our pilot study are listed in Table 1.

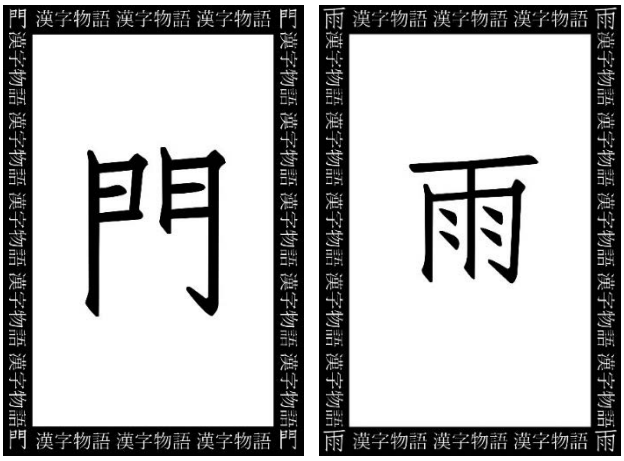


Figure 6. Sample cards from the 漢字物語 application.

Table 1. Heuristics from Shoukry et al.'s pre-MEGA framework (2015)

Category	Guidelines/heuristics
Ease of use	Consistent responses to user interactions
Responsiveness	Short, interruptible routines and animations
Learning potential	Offer sufficient amount of content
Content delivery	Based on real-life experiences and related to socio-cultural context
	Introduce concepts through many entry points
	Support with high-quality graphics, audio and visual effects
	Stimulate further inquiry
Pedagogical agent	Context-appropriate visual representation

漢字物語: Ami's Life in Japan

The first version of the application tells the story of exchange student Ami's life in Japan. When the user selects one of the AR cards (shown in Figure 6), the card triggers an animation in which Ami is the focal point (see sample animation frames in Figure 7). For example, the kanji for *mountain* triggers an animation in which Ami climbs Mount Fuji during cherry blossom season. In another example, the card for *rain* triggers an animation in which Ami decides to listen to music on her mp3 player while sitting next to a window on a rainy day. In the third example shown here, if the user chooses the card for *fire*, an animation will play that shows Ami wearing a kimono next to a large bonfire for the Daimonji festival in Kyoto.

Figure 7. Images from the character-driven version follow Ami, at various points of her story.

In this version of Storytelling Kanji, we designed a pedagogical, narrative agent to help the user experience the meaning of each kanji through short stories featuring this character. The name Ami was chosen as it could represent the short form of a female name in several different cultures.

Ami is meant to be a character that the user can relate to – she is new to learning kanji and is exploring them as student along with the user. Vignettes represent short, interruptible animations that are based on real-life experiences and related to the learner's socio-cultural context.

漢字物語: Kanji as Storytellers

Where the first version of the *Storytelling Kanji* application featured a single character, we also wanted to explore a simpler form of visual storytelling that placed greater focus on the kanji themselves. Visual designs for this second version, *Kanji as Storytellers*, were inspired by original pictographic scripts (e.g., oracle bone script) in addition to exploring the meanings of radicals that contribute to the overall shape of each kanji. For example, Figure 8 shows three frames from the animation for the character for *sun*, starting with the modern kanji, shifting to the historical pictograph, and arriving at a contemporary visual representation of the kanji's meaning.

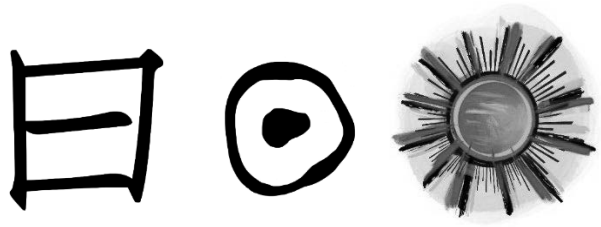


Figure 8. Storyboard for the "sun" animation. The animation incorporates the historical pictograph.

We were additionally inspired by folklore surrounding the meanings of different kanji. For example, when designing the character for *woman* we considered a typical image, such as a woman wearing a kimono. The shape of this image matches the shape of the kanji and conveys its meaning effectively. However, looking to the history of this kanji we were also inspired by the kunoichi – female ninja practitioners. The term kunoichi appears in the eighth volume of the ninja handbook Bansenshukai written in the late 17th century. The text describes *Kunoichi-no-jutsu*, translated as "a technique to use a female" (Katsuya Yoshimaru, 2017, p. 170). The word is thought to derive from the sounds of characters that resemble the three strokes in the kanji character in order:

"く" is a hiragana character pronounced "ku"

"ノ" is a katakana character pronounced "no"

"一" is a kanji character pronounced "ichi" (and meaning "one").

Figure 9. Two designs for the character "woman"

The two versions of this character are shown in Figure 9. Although the first variant is more common to kanji learning applications, we were eager to explore a more unique design that was rich with history which would hopefully stimulate further inquiry as per our targeted heuristics.

Implementation

We explored two versions of the application. Both versions used a printed kanji card to trigger animations (see Figure 6). The first was sensor-based using radio-frequency identification tags (RFID) to trigger animation sequences (see Figure 10). This RFID sticker was affixed to the back of the printed cards. When positioned over a card reader, it would trigger animations in the application. The second version was designed to use the kanji themselves as a sort of fiducial marker to trigger animations using the built-in camera on any mobile technology (e.g., tablet or smartphone).

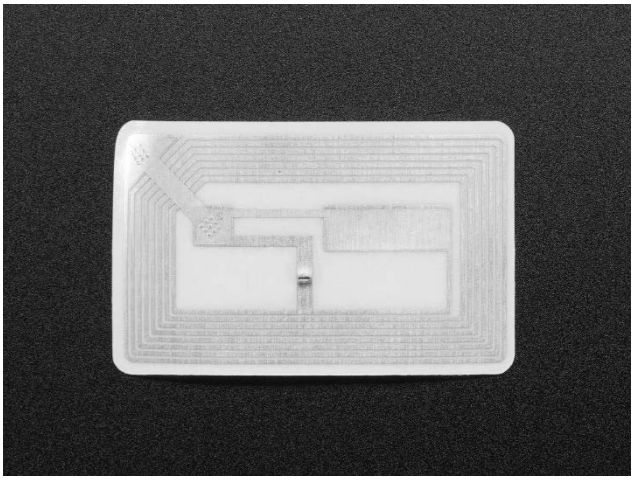


Figure 10. The 13.56MHz RFID/NFC Sticker

The image-based AR application was built in the Unity editor 2017.3.1 and Vuforia software development kit (SDK) for Android. The Android SDK is also required for compilation. The Unity engine allows developers to produce applications for PC, Android, and iOS using the Unity graphic engine. Vuforia is an augmented reality SDK for mobile devices which uses computer vision to recognize visual markers and link them to virtual content. The Vuforia SDK is available for Android Studio, XCode and Unity.

We were inspired to keep the card design simple so that the visual focus would be on the kanji. However, when assigning visual markers in AR, a high degree of "visual complexity" is required in order to ensure that the marker is recognized quickly by the application. The cards developed by Lin et al. (2009) paired kanji radicals with fiducial markers. Fortunately, due to advances in computer vision since their study, we were able to design a less conspicuous marker in our card design.

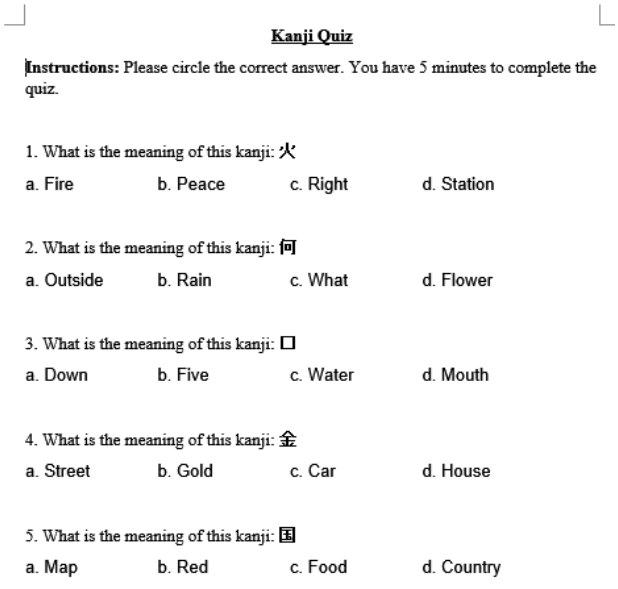
Vuforia uses a five-star rating system to help developers evaluate the quality of an image as a potential AR marker. Many kanji scored only one or two stars, requiring us to try different designs. We settled on the design shown in Figure 6, which incorporates a thick black border and the name of the application 漢字物語 alongside the kanji displayed on the card. This design allowed us to keep the visual focus on the kanji and produced a 4- or 5-star rating. Due to the limitations of visually tracked markers, it is possible for the wrong animation to be triggered on occasion (especially if viewed in low light). However, we opted to pursue development of this version of the app in this phase of the research project due to the ease of distribution with a marker-based design.

With the marker-based implementation, AR content is accessed by viewing individual kanji cards through the built-in mobile camera via the *Storytelling Kanji* app. In these vignettes, individual kanji come alive. For example, when a student views the card for *river* through the app, the kanji begins to animate and becomes a flowing river while river sounds play in the background. If a student views the card for *tree,* the lines of the kanji morph into the trunk and branches of a tree full of leaves whose faint rustling can be heard.

The Marker-less (RFID) application was built using Unity and Arduino. RFID stickers are affixed to the back of each kanji card. When the card is placed on top of the card reader, an animation is triggered by the application. This animation can either play on the computer screen or can be projected onto a wall for larger-scale installation.

Pilot Test

This study utilized participant observation methods from the discipline of Human-Computer Interaction. At the start of the study, participants were asked to fill out a brief survey to capture demographic information and to identify each participant's prior experience studying the Japanese language (e.g., age, number of years studying Japanese in a formal setting, number of years self-taught, time spent in Japan, etc.). Following this, participants took a short quiz (pre-test) to evaluate their pre-existing knowledge of kanji. Following this, participants spent approximately 30 minutes with the application. Kanji cards were printed cardstock and the application was accessed using an Android tablet. At the conclusion of the study, the participant takes a post-test quiz and answers a brief survey designed to assess user experience.



Kanji Quiz

Instructions: Please circle the correct answer. You have 5 minutes to complete the quiz.

1. What is the meaning of this kanji: 火

a. Fire b. Peace c. Right d. Station

2. What is the meaning of this kanji: 何

a. Outside b. Rain c. What d. Flower

3. What is the meaning of this kanji: 口

a. Down b. Five c. Water d. Mouth

4. What is the meaning of this kanji: 金

a. Street b. Gold c. Car d. House

5. What is the meaning of this kanji: 国

a. Map b. Red c. Food d. Country

Figure 11. Sample questions from the pre-test

The focus on pilot testing was primarily to assess application usability and user experience (e.g., ease of use, enjoyment, etc.). However, preliminary results indicate that the design of the application, particularly the storytelling aspect, was especially enjoyed by participants as it differed from traditional kanji learning applications. Furthermore, users indicated that the ability to use the printed cards alone or with the application was an appealing feature of the design. In our future work, we intend to expand on the design of the application, incorporating other aspects of kanji knowledge, and conduct longitudinal studies with participants.

Conclusions and Future Work

In this paper, we presented a design history of a visual, narrative-based Augmented Reality application designed to support non-native learners of kanji. Two visual narrative designs were presented along with two different technological implementations: marker-based and marker-less (RFID). Pilot tests with the Storytelling Kanji have increased learner interest in exploring kanji beyond memorization – expressing interest in the cultural and historical aspects of the alphabet itself. Although Storytelling Kanji presently lacks any ludic features, we propose that the interactive narrative aspect of the project highlights the future potential for AR games to impact Japanese language studies outside of Japan.

Each type of implementation introduces strengths and weaknesses. The RFID version is more accurate at triggering animations and is not dependent on lighting or the complexity of the card design. RFID also allows for more complex user interactions. Despite the complications in implementing a visual marker-based kanji application, this version is easily distributed online and supports rapid prototyping. For this reason, we intend to pursue the marker-based version of the application in the next phase of this research. Our goal is to eventually distribute the application for free online and to host the cards as printable PDFs that can be downloaded by anyone to use with the app.

In the next phase of our research, we intend to conduct longitudinal studies of first-time Japanese learners on our campus. We have further plans to expand the Storytelling Kanji into a more complex application with gamified elements tied to both the vignettes themselves, as well as kanji learning activities that allow students to generate more complex narratives using the kanji cards.

The design of the vignettes presented herein were designed by the principal investigator. In addition to the longitudinal studies noted above, we are also interested in taking a participatory approach to the visual designs of the vignettes, engaging with both native and non-native speakers of Japanese in collaboratively exploring alternative designs.

Acknowledgements

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