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Research Article

# Developing immersive learning experiences for “Emaki-mono” Japanese historical narrative picture scrolls



## Research Themes

Immersive Learning, Virtual Reality, Japanese Culture, Japanese Art, Japanese History

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## ABSTRACT

# Developing immersive learning experiences for “Emaki-mono”, Japanese historical narrative picture scrolls.

Classic literature is one of the lowest favored subjects among Japanese middle school students. Information and communication technology (ICT), including virtual reality (VR), has been used to make the subject more engaging and easier to understand for students who are rarely exposed to traditional linguistic culture. In this study, we developed VR Ban Dainagon Emaki, a virtual reality application for learning a traditional Japanese picture scroll. Emaki is even harder than other Japanese classic literature works because of the size (~ tens of meters), missing texts, and varied interpretations. In this app, students can view the whole scroll of an emaki in a virtual space and grasp the "big picture" of the story which runs along the scroll. Learning of the story and the characters on the scroll are further enhanced by added voiceovers, subtitles as well highly expressive animations. Future works may include enabling social learning using so-called "metaverse" platforms such as Mozilla Hubs.

# Authors



**Kojiro Yano**

*Osaka Institute of  
Technology*

Kojiro Yano is a professor at the Osaka Institute of Technology. After obtaining his Ph.D. from the University of Liverpool, he moved to the University of Cambridge, where he worked as a postdoctoral fellow and later as a senior research associate. In 2011, he returned to Japan to accept his current position at the Osaka Institute of Technology, where he began working on educational technology, particularly in STEM and TESOL. His current research interest is the application of VR and AI to education. He is also involved in various projects aimed at facilitating the introduction of VR technology in schools. His Facebook group, "Teachers' Tips for VR," is the largest SNS group for VR education in Japan. He is an editor of the journal *Computer & Education*.



**Eri Yokoyama**

*Osaka Institute of  
Technology*

Eri Yokoyama is an associate professor at the Osaka Institute of Technology. She received her Ph.D. in Literature from Nara Women's University in 2016. She specializes in Japanese classical literature, particularly in the history of the reception of *The Tale of Genji*. She has been awarded the academic prize as the first author of the Best Paper Award at the 7th IEEEJ International Conference on Image Electronics and Visual Computing (IEVC2021). Her paper, titled "A Digital Transformative Education Method for Japanese Classical Literature - Hyakunin-Isshu E-Learning Application," was selected for this honor.

## CONTEXT

# Watch the Presentation

### *Recording of the online presentation on this research*

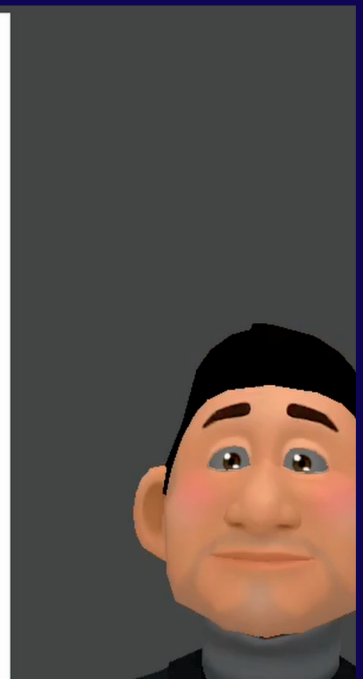
To foster a holistic discussion, the forum will amass a diverse group of stakeholders, spanning from software developers to educators and students. These participants bring to the table multifaceted experiences and insights, making for enriching dialogues.



### **Developing immersive learning experiences for “Emaki-mono”, Japanese historical narrative picture scrolls.**

Kojiro Yano & Eri Yokoyama  
Osaka Institute of Technology, Osaka, Japan

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## BACKGROUND

### The Convergence of Two Curves: Exponential Growth and Gartner Hype Cycle

According to The Courses of Study for Middle Schools by the Ministry of Education, Culture, Sports, Science and Technology (MEXT) Japan, students learn traditional linguistic culture in the subject of Japanese Language("KOKUGO"). More specifically, students are expected to have opportunities "to be exposed to the world of classic literature," and "enjoy the world", as well as "to be exposed to the viewpoints and ways of thinking expressed in classic literature and imagine the characters and author's thoughts."

On the other hand, according to a MEXT's survey, only 29.3% of middle schools students gave positive responses (Yes or Probably Yes) to the question " Do you enjoy learning classic literature". This is a much smaller percentage than Japanese Language (57.5%), Math (55.7%), or English Language (53.3%), and this tendency persists in high school students. Moreover, in another survey by MEXT, 71.2% and 72.1% of the high school students gave negative responses, respectively, to the question "Do you like classical literature and Chinese classics?". MEXT claimed that the main reason was the excessive teaching of elementary knowledge and techniques, thus leading to boredom and dislike of learning. The solutions they suggested were as follows. First of all, teachers should educate not only by teaching original texts but also by devising educational tools so that their students can touch how ancient people saw, felt, and thought of things at that time. Secondly, teachers should enhance and deepen this teaching method to augment the interest and motivation of the students.

## BACKGROUND

One of the possibilities to address this problem is using information and communication technologies (ICT). The Courses of Study states that "each school should put in place the necessary environment for information devices, such as computers and information and communications networks, etc., and enhance learning activities by properly utilizing these devices." GIGA School Concept by the Japanese government, which includes a plan to provide a computer to each student by the end of March 2023 (Sato, 2020), and the sudden shutdowns of classrooms due to COVID-19 have accelerated the use of ICT at Japanese schools. And ICT can encourage students to be interested and enjoy classic literature as well as better understand the works.



## BACKGROUND

# Teaching Classic Literature Using ICT

Large-scale literature databases, including Database of Pre-Modern Japanese Works of National Institute of Japanese Literature (<https://kotenseki.nijl.ac.jp/>) and National Diet Library Digital Collections (<http://dl.ndl.go.jp/>) were released in 2017. Although this has led to the use of digital images in educational settings, few practical examples have been reported.

In the faculty of Information Science and Technology in Osaka Institute of Technology, there were two literature classes, namely “Elementary Literature” and “Literature With Visual Representation” as the social sciences and humanities field in the general education course. These literature courses were linked tightly with information technology and aimed at making students feel literature familiar to them. By introducing Web/smartphone applications into the classes, it was expected to encourage students to concentrate on historical content and to further understand the meaning and backgrounds of literary works through discussion and mutual communications by group works. The content included pictures from illustrated scrolls (Emaki or Emakimono) on a folding screen. They were turned into puzzle games and manipulated by students (Yokoyama et al., 2020)

## BACKGROUND

# Teaching Classic Literature Using ICT

In the Heian period, illustrated scrolls were highly popular. The earliest extant examples date from the 12th century. They include fictional tales such as the famous Genji Monogatari Emaki (Picture Scroll of the Tale of Genji). Here excerpts from the text are alternated to paintings of representative scenes. This format quickly gained favor and was used continuously throughout the medieval period and into the Edo period. However, emaki is difficult to understand without knowing what the scene implies. By transforming the original picture of Genji Monogatari Emaki into many pieces of a jigsaw puzzle, the app encouraged students to concentrate on details of the scene, particularly the four borders, and come to understand what the scene describes. As the Genji pictures have some distinct characteristics, e.g., interior description, this application helped the students to understand the work more deeply and effectively. Surveys of students who used the app suggested that using the app was not just fun but also contributed to changing their attitude toward learning classic literature in a positive way.



## METHODOLOGY

# Learning classic literature in VR

In this article, we focus on the use of VR for learning classic literature. Thanks to the recent development in both software and hardware environments, access to VR experiences has become far more straightforward now. And now VR is being used in education for various subjects (Kavanagh et al., 2017). It has been shown in a number of studies that VR can significantly enhance the motivation of students to learn and help them to stay focused on learning by immersing them in the experiences. This feeling of immersion can encourage students to empathize with people, namely, understand people's situations by experiencing the simulated ones firsthand (Schutte & Stilinović, 2017). Finally, VR can let students interact with the objects in the synthetic environment as they would do in physical reality. This "embodiment" (Johnson-Glenberg et al., 2020) helps students solidify their knowledge that is more transferable to real life than those which are learned by just listening to lectures or reading books. This is most readily demonstrated in vocational training, such as performing physical examinations of patients (Grundman et al., 2000) or weld cast iron (Huang et al., 2020).

## BACKGROUND

### Learning classic literature in VR

While the application of VR in education is most often found in foreign language, healthcare, and STEM fields, there are examples of VR-assisted learning in classic literature too. For instance, Lopez Bravo (Bravo, 2020) used a series of 360-degree images of places related to *Genji Monogatari* (Tale of Genji) to help students critically engage with the places where the story was set and originated and understand the context of the story. Harvey et al. developed an education program for Shakespeare that included VR experience of Globe Theater, where many of his plays were performed (Harvey et al., 2020). This allowed students to inspect the features of the theatre, such as the stage and seating arrangements and gain insights into how Shakespeare's works were performed. While the most immersive experience would be afforded by full 3D CG modeling of virtual scenes, it is challenging to prepare 3D assets to construct scenes since available image resources for classical literature are mostly 2D. To bridge this gap, Zhao & Xiaojuan created ShadowPlay2.5D, which combined 2D images of characters and backgrounds from classic Chinese literature in a 3D environment (Zhao & Xiaojuan, 2020). Users could manipulate the characters like puppets and tell stories in front of the camera and record it as a 360-degree video.

## VR Bandainagon Emaki

### VR Bandainagon Emaki

As one of such efforts, we developed VR Bandainagon Emaki, a virtual reality experience for learning a Japanese traditional picture scroll. Bandainagon Emaki is said to have been made in the late Heian period, around the 12th century. It is a narrative picture scroll depicting the Otenmon Incident in 866. As a typical example of the feature of emaki, the first roll of Bandainagon Emaki has scenery of fire at Otenmon (the red-painted front gate), which depicts flaring Otenmon, crowds of viewers, government officers trotting down on to the site upon receiving information, and so on, in a few meters long series of pictures.

Learning classic literature is not easy for students, but learning Emaki involves further challenges. Since an emaki is primarily composed of images accompanied by short texts as summaries, understanding its story is far more complex than novels if you do not have sufficient background knowledge. In the case of Bandainagon Emaki, many of the original texts are missing, making the interpretation even more difficult. Another challenge is related to the way an Emaki's story is told. Emaki is not just a panoramic image of a particular scene but a sequence of pictures that are shown in a loosely chronological order to construct a visual story. Therefore, readers must understand how a section of the emaki is related to the preceding and following sections in a narrative sense. However, because Emaki is a long picture scroll (the first volume of Bandainagon Emaki is about 8.4meter), only a narrow stretch of the Emaki can be shown on each page of a textbook or a screen, making it harder for students to follow the flow of the story.

## VR Bandainagon Emaki

This difficulty of watching Emaki as a whole may be resolved by the use of VR. First of all, students can easily view the whole scroll of an Emaki in a virtual space since there is no limit for the display size. If you surround them with the scroll, they only have to rotate their head to skim through it. This would help students to understand how the story of an emaki is organized and easily grasp, literally, the big picture of the story. The second benefit of using VR is to make students more interested in the characters on an Emaki. As discussed above, it is well known that seeing people in an immersive environment makes the users feel empathetic toward them. Since understanding the feeling of characters is one of the goals of learning Classic literature, feeling a connection with them through VR experiences can be highly beneficial.



One of the earlier examples of Emaki experience in VR, Waseda University library used a series of 360-degree images of Genji Monogatari Emaki : Shiki Genji (The Tale of Genji) and produced a 3D 360 video with narrations to explain the story told on the emaki. While this video gives a panoramic view of emaki and a feeling of immersion if experienced in VR HMD, it is not possible to move in the virtual space and take a closer look at the images, nor have interactions with the objects on the scroll.

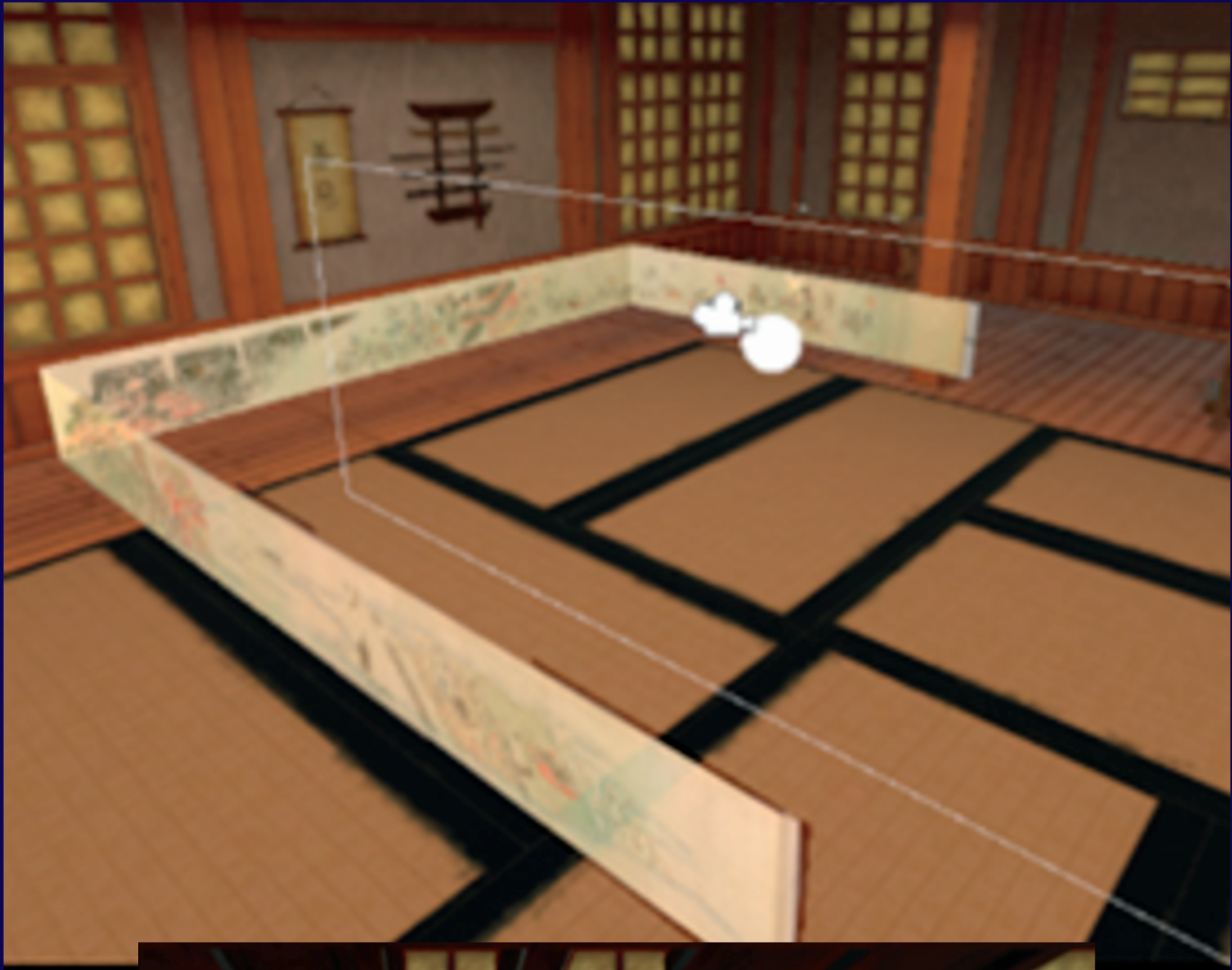
## VR Bandainagon Emaki

Therefore, VR Bandainagon Emaki implements a combination of 2D flat images, a 360-degree image, and 3D virtual space. For this VR app, we obtained the photos of the Emaki from National Diet Library Digital Collections and stiched them together into three images, and arranged them in a C shape. We avoided transforming them into a spherical panorama because it can distort the images. The three images correspond to the scenes in the story: the first part describes people were rushing to the gate where the fire accident was happening, the second part shows the burning gate, and the third part hints at who plotted the arson.

The background image is a Japanese temple, and it is implemented as a static 360-degree image since this can be rendered lighter than the full 3DCG model and, therefore, suitable for mobile VR devices with limited graphic resources. The Emaki images and the 360-degree background image are placed in a 3D space where users can walk in the virtual room, take a closer look at the Emaki or just look around to experience the world of the Emaki in an immersive fashion.



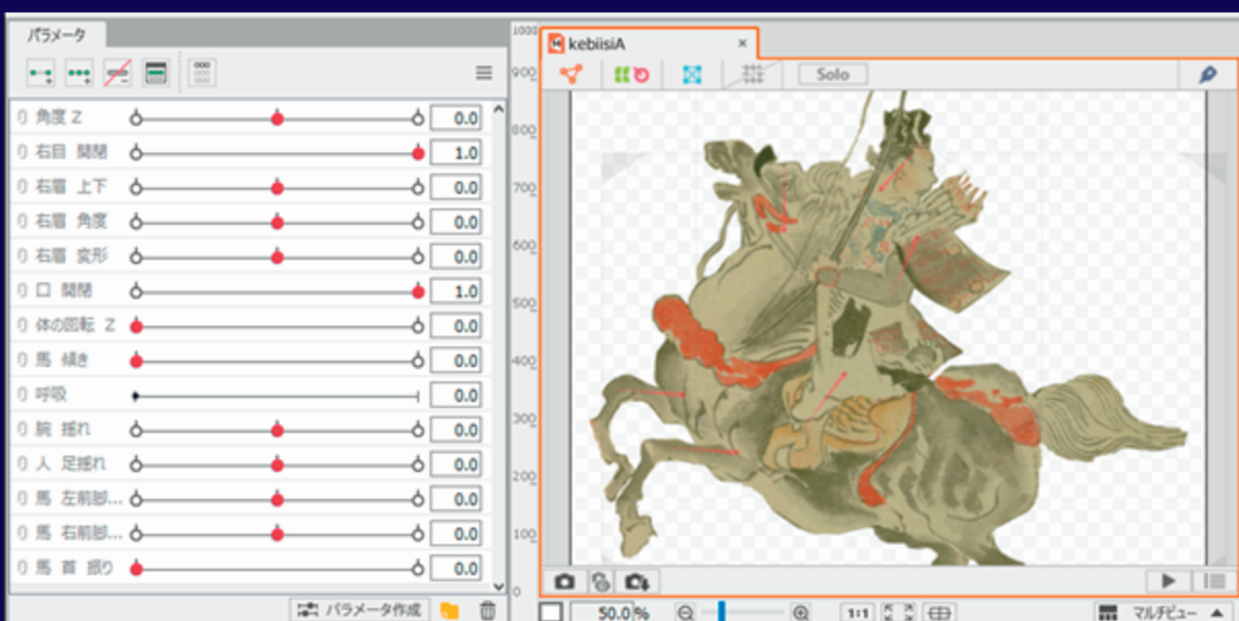
# VR Bandainagon Emaki



## VR Bandainagon Emaki

**“These expressions greatly expand the expressiveness of characters and enable the characters to play out the stories more effectively.”**

In addition to the immersive viewing of the emaki, we tested interactive elements for embodiment. In VR Bandainagon Emaki, we animated the characters using Live2D Cubism (<https://www.live2d.com/>), a 2D animation authoring tool widely used for games and anime. Live2D allows animated 2D characters directly from source images. We extracted characters from Emaki images on Adobe Photoshop and applied "art meshes" (polygons), which can be deformed by parameters. The meshes can be applied to different parts of the character's body, such as eyes, mouth, head, and limbs, and changing their shapes by adjusting the parameters allows expressions like blinking, talking, nodding, or running. These expressions greatly expand the expressiveness of characters and enable the characters to play out the stories more effectively. While there are no dialogues for characters in Bandainagon Emaki, we assigned words to some of the characters to clarify their roles in the story



## VR Bandainagon Emaki

The VR app, developed on Unity game engine, was made available first for Oculus Go (3DOF HMD) and later for VIVE Focus Plus (6DOF HMD). While the players use the controller to move around in the oculus GO version, they can walk around freely in the later VIVE Focus plus version with positional tracking. In both versions, there are buttons below interactable characters, and animations are played with voices and subtitles when they are pressed. However, when children experienced the VR apps, they often struggled with pointing the buttons in VR with the controller and pulling the trigger to activate the button. In the later version for VIVE Focus Plus, we added a "touch bar" to the controller in the virtual space, and the buttons were modified to be triggered by piercing them with the bar for a certain period.

Finally, VR can allow multiple users to view an Emaki together. Organizing students into groups and letting them work as a team to discuss the interpretation of an Emaki can improve the motivation of students and the understanding of source materials. One of the authors has practiced an active learning approach of Emaki teaching by printing out the whole Emaki and letting the students annotate it together by pasting postits. This practice was possible because wide blank walls were available at the college, but for those who do not have access to such space, VR can be used instead. We took the images from the original VR Bandainagon Emaki and installed them into a scene of Mozilla Hubs, a social VR platform, for multiplayer experiences. Unlike the original VR Bandainagon Emaki which was developed as a single user standalone software for VR HMDs, this Mozilla Hubs version was built as a WebXR app and viewable on both PC browsers and VRHMDs. A Mozilla Hubs room can be shared with other users by a URL, and they can have conversations and add objects (e.g., images, marker lines) together. This would allow students to have discussions and annotate the emaki in a virtual space. Currently, only text and audio annotations are used for learning aids, but we plan to add character animations, as in the original VR Bandainagon Emaki, to this experience.



## CONCLUSIONS

### **Experiencing Emaki in VR or touching image content through tablet apps can motivate students**

As described above, the MEXT expects teachers to help their students better perceive how ancient people saw, felt, and thought in the past. We believe our applications for Emaki would fulfill such requirements. There are three points we would like to emphasize.

(1) Lessons using VR or tablet apps can close the distance between classical literature and students. Experiencing Emaki in VR or touching image content through tablet apps can motivate students who are reluctant to study the subject. In a lesson about traditional Emaki, for example, the teacher can focus on the part he/she attaches importance to without having to go into details about techniques to appreciate the works.

(2)VR creates a traditional Japanese cultural space. It gives the students an opportunity to experience how ancient people might have seen, felt, and thought at the time, which the MEXT prioritizes for literature education.

(3)Each student can use the apps at his/her own pace. For example, group works using the puzzle game can deliver his/her opinions or awareness to a literature work by the message card function. Similarly, students can paste their comments to the scroll and share them with other students in the Mozilla Hubs version of VR Bandainagon emaki. As the learning progresses, such opinions can be revised or enhanced. Through this process, students will understand the benefit of cooperation with other students to appreciate classic literature in a manner that would not have been possible on their own. Thus, VR Bandainagon Emaki and the applications are expected to help students deepen their study in multiple ways.

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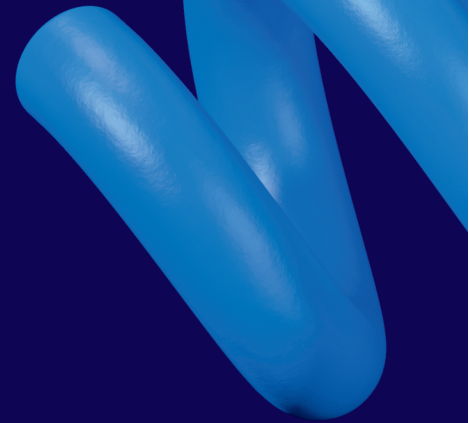
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## ABOUT THE EDITOR

Eric is a learning futurist, tinkering with and designing technologies that may better inform the future of teaching and learning. Eric's projects have included augmented tourism rallies, AR community art exhibitions, mixed reality escape rooms, and other experiments in immersive technology.



ERIC  
HAWKINSON  
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