Proceedings of International Conference on Technology and Social Science 2018 (ICTSS 2018)
Keynote Lecture

Review of Augmented and Virtual Reality for Middle School Science Education

Yuki Aoki

Faculty of Education, Gunma University, 4-2 Aramaki-machi, Maebashi, Gunma 371-8510, Japan

<y-aoki@gunma-u.ac.jp>

Keywords: science education, information and communications technology, tablet

Abstract. The global market for Augmented Reality (AR) and Virtual Reality (VR) has been growing rapidly in recent years. The use of these technologies for educational purposes has become important, because AR and VR can be experienced using the tablet computers deployed at each school. In order to use AR and VR in education, the development of teaching materials conforming to compulsory educational guidelines is necessary. We have developed AR and VR teaching aids that are suitable for middle school science education in each grade.

1. Introduction

The introduction and diffusion of Information and Communication Technology (ICT) within the sphere of education is now an important subject globally [1]. With respect to the broader context of this subject, commentators frequently mention the revolution that is currently occurring within manufacturing and industry. Driving this new industrial revolution, referred to as "Industry 4.0," are three innovative technologies: Artificial Intelligence (AI), the Internet of Things (IoT), and Big Data (BD). Together, they promise to self-reliance industry even further [2, 3]. It is estimated that in ten to twenty years from now, approximately half of all jobs that until today have been done by human beings will be taken over by self-reliance machines making use of this combination of AI, the IoT, and BD [4]. For this reason, the children of today will work in jobs that as of yet have not been created, and, indeed, they will be the ones who will go on to create those very jobs. For this reason, the introduction of ICT into the education curriculum is increasingly necessary to develop the talents of individuals who will go on to utilize AI, the IoT, and BD, and create new jobs in the process.

As part of the process of fostering ICT education, the Japanese government has set the goal of ensuring that by 2020 there will be a tablet available for every child for compulsory education classes. The aim is to establish a learning environment where children use tablets as yet another tool to help them learn. Although there has been an increase in opportunities for teachers to use tablets when conducting lessons, all that this has effectively amounted to is the display of digital contents. That is, such tools have not as yet been properly incorporated into the education of AI, the IoT, and BD. In regard to the IoT in particular, it is possible to use the sensors that current tablets are equipped with in classes that observe scientific phenomenon. For example, educational methods utilizing sensors for measuring have already been developed for use in teaching about mechanics, and Real-time measurement by way of sensors has been shown to have a positive effect on learning [5]. In recent years, it has become possible to allow learners to more directly and intuitively understand the results of such sensor measurements by way of technology that also uses sensors, known as Augmented Reality (AR) and Virtual Reality (VR) [6-8].

As I shall introduce in this paper, as part of my investigation into using tablets in a future IoT, I have developed a teaching aid that carries its own sensors. In particular, I will discuss the development of a teaching aid for middle school science classes that allows for the visualization, by way of AR and VR, of scientific phenomena that are not visible to the naked eye, such as sound waves and electromagnetic induction.

2. Development of Teaching Aids

For our tablets, we utilized the Nexus 7 (2013) by Asus. Among other things, this tablet comes equipped with standard sensors that include a camera, speaker, microphone, magnetometer, gyroscope, accelerometer, global positioning system (GPS), and near field communication (NFC). (Fig. 1).
Using these sensors, we developed AR and VR teaching aids that would be suitable for science education in each grade of middle school. For first-year middle school students, we developed an AR teaching aid that would render in visual form the process of the transmission and reception of sound waves. For second-year middle school students, we developed a teaching aid that uses NFC to show how non-contact power supplies work in order to demonstrate the uses of electromagnetic induction. In order to help teach the principles of electromagnetic induction, we also developed an AR teaching aid which would allow for visualization of magnetic lines in a virtual coil. For third-year middle school students, we developed a VR teaching aid that would help them learn about the diurnal motion of celestial objects. In the following sections, I will introduce some of the details for each of the teaching aids. In each case, software development was conducted in Unity.

Fig. 1. Nexus 7 (2013) model. Each sensor is used as an AR or VR teaching aid for 7th grade students (I), 8th grade students (II) and 9th grade students (III)

2.1 Sound Visualization by AR (for first-year middle school students)

To help first-year middle school students study about sound waves, we used AR to create a teaching aid that would render sound waves visible (Fig. 2). With this teaching aid, we used the sensors denoted by "I" in Fig. 1. The sine wives transmitted from the tablet originate from the AR marker over the speaker on the left side of Fig 2. Using AR, the changes in air density caused by transmission of the sound waves are shown in red (high density) and blue (low density). The passing of time in the AR space was set to 1/1000 of real time, so that the students could study the process of transmission of compressed waves. The students were able to change the amplitude and frequency and by doing so, change the AR visualization as well. Furthermore, as a method for visualizing the process by which transmitted sound waves are received, we enabled the AR display of the oscilloscope waves taken from observation of the phenomenon. These were displayed over the Microphone AR marker on the right side of Fig 2.

In the preceding research concerning the visualization of sound-waves using AR, sound-waves were displayed in AR as circular waves, and teaching aids for studying the transmission process were developed [9]. With the teaching aids developed for this research, however, we focused on the dynamic visualization of the reception process, rather than on the sound-wave transmission process. This approach enables students to study the dynamic process by which oscilloscope waveforms are drawn.

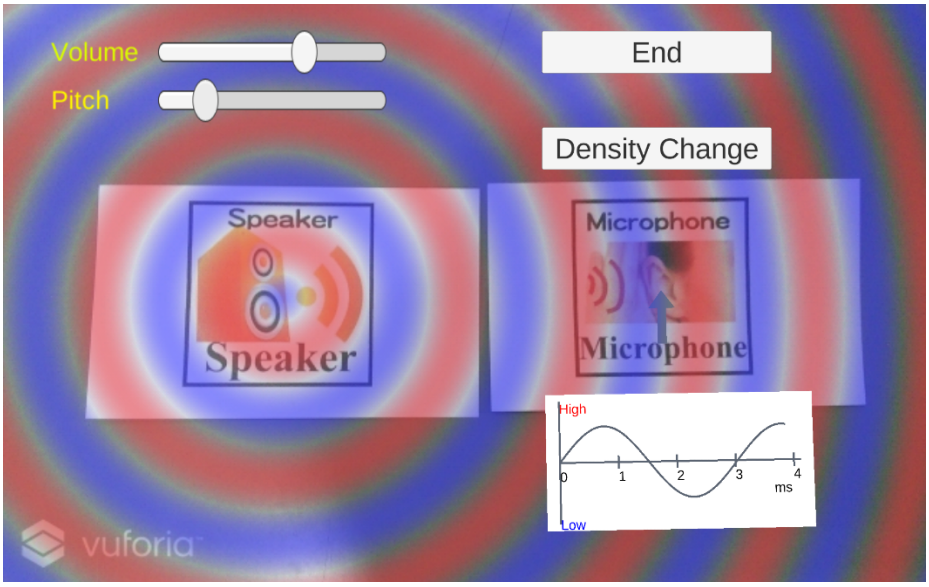

Fig. 2. Screenshot of the sound-visualizing AR teaching aid using the rear-facing camera and the speaker

2.2 Magnetic Lines Visualization by AR (for second-year middle school students)

To help second-year middle school students study of electromagnetic induction, we used an NFC coil to demonstrate wireless charging (Fig. 3(a)). We also developed a teaching aid that would enable the visualization of the principle behind the occurrence of an induced current (Fig. 3(b)) [10]. For this teaching aid, we used the sensors noted by (II) in Fig 1. In recent years, many smartphones and tablets come equipped with an NFC coil that transmits at a frequency of 13.56 MHz. With our teaching aid, students were able to use this coil in order to study electromagnetic induction while the device was in use. With the NFC coil, we created a virtual coil that would flash with an LED. Furthermore, we wished for students to be able to receive an intuitive understanding of the principle guiding the occurrence of electromagnetic induction in the coil. For this purpose, we used a magnetometer inside a tablet, so that if a magnet is moved about in relation to the virtual coil, which is displayed on the tablet screen, the direction and number of magnetic lines of force within the displayed coil would change. We designed this system so that when the magnetic flux density changed, the LED shown in the photo would light up.

In the preceding research, an AR teaching aid was developed that would display magnetic lines of force in 3D [11]. In this research, we developed a teaching aid that would also use a tablet in order to help students actually experience wireless charging.

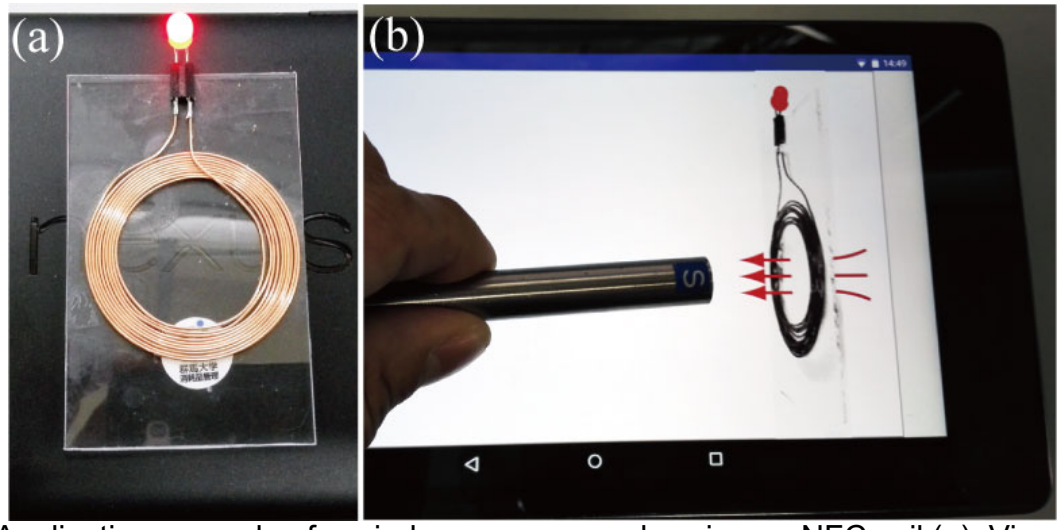

Fig. 3. Application example of a wireless power supply using an NFC coil (a). Visualization of magnetic lines with AR using the magnetometer (b)

2.3 Visualization of Diurnal Motion by VR (for third-year middle school students)

To help third-year middle school students study the diurnal motion of stars, we developed a teaching aid that uses VR (Fig. 3). For this teaching aid, we made use of the sensor noted by (III) in Fig. 1. There have been many VR teaching aids created for the purpose of studying celestial objects [12]. What is unique about the teaching aid we created, however, is that students are able to grasp the tablet in their hand and use their own physical movement to help them develop an understanding of the movement of the stars.

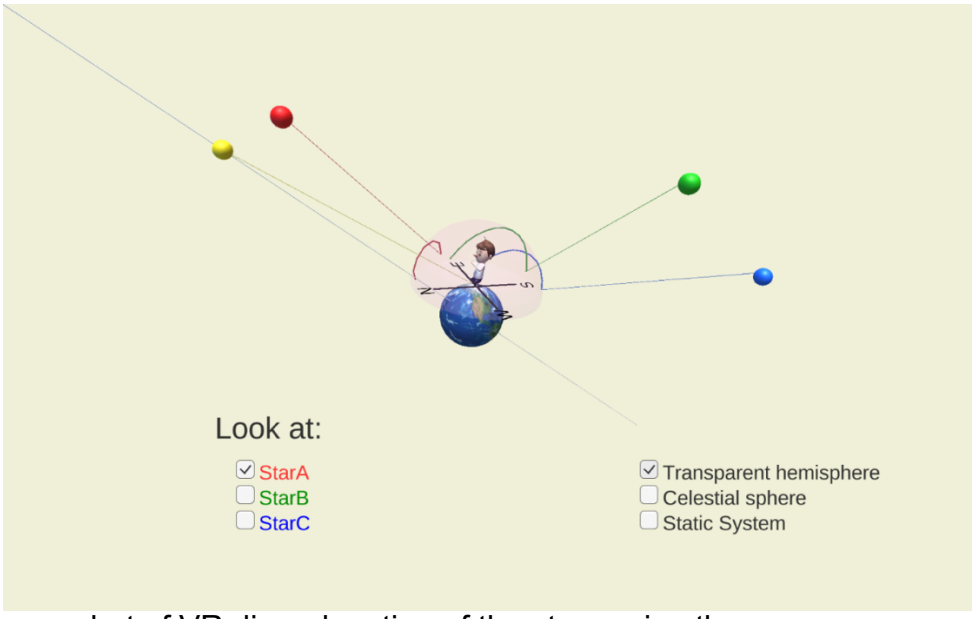

Fig. 4. Screenshot of VR diurnal motion of the stars using the gyroscope

3. Conclusion

In this research, we investigated the utilization of tablet ICT for education purposes. By using the

sensors available in a tablet, we were able to develop teaching aids that would enable students to intuitively understand scientific phenomena via AR and VR. The use of AR and VR in tablet-based education is quickly expanding globally, but without the development of an adequate number and variety of teaching aids [13]. In Japan, however, as the use of tablets in compulsory education is being actively promoted, it is particularly important to develop teaching aids that meet the needs of learners. At present, there are still few AR or VR teaching aids that can actually be used in school. Our intention in this research, therefore, was to develop teaching aids that would serve the needs of compulsory education classes for each of the different year groups at a middle school. Going forward, it will be necessary to carry out in-class testing of each of the teaching aids in order to verify their educational effectiveness. Furthermore, it will be necessary to develop AR and VR teaching aids for non-science classes.

Acknowledgements

This work was supported by JSPS KAKENHI Grant Number JP17K04844.

References

[1] R. B. Kozma, "National Policies that Connect ICT-Based Education Reform to Economic and Social Development," ***Human Technology***, Vol. 1, No. 2, pp. 117-156, 2005.

[2] S. Wang, J. Wan and C. Zhang, "Implementing Smart Factory of Industry 4.0: An Outlook," ***Int. J. Dist. Sensor Networks***, Vol. 2016, No. 3159805, pp. 1-10, 2016.

[3] H. Lasi, H. G. Kemper, P. Fettke, T. Feld and M. Hoffmann, "Industry 4.0," ***Business & Information Systems Engineering***, Vol. 4, pp. 239-242, 2014.

[4] C. B. Frey and M. A. Osborne, "The future of employment: How susceptible are jobs to computerization," ***Technol. Forecast. Soc. Change***, Vol. 114, pp. 254-280, 2017.

[5] R. K. Thornton and D. R. Sokoloff, "Assessing student learning of Newton's laws: The force and motion conceptual evaluation and the evaluation of active learning laboratory and lecture curricula," ***Am. J. Phys.***, Vol. 66, No. 4, pp. 338-352, 1998.

[6] Z. Pan, A. D. Cheok, H. Yang, J. Zhu and J. Shi, "Virtual reality and mixed reality learning environments," ***Computers & Graphics***, Vol. 30, No. 1, pp. 20-28, 2006.

[7] S. C. Y. Yuen, G. Yaoyneyong and E. Johnson, "Augmented Reality: An overview and five directions for AR in education," ***JETDE***, Vol. 4, No. 1, pp. 119-140, 2011.

[8] H. K. Wu, S. W. Y. Lee, H. Y. Chang and J. C. Liang, "Current status, opportunities and challenges of augmented reality in education," ***Computers & Graphics***, Vol. 62, pp. 41-49, 2013.

[9] H. Salmi, A. Kaasinen and V. Kallunki, "Towards an open learning environment via Augmented Reality (AR): visualizing the invisible in science centres and schools for teacher education," ***Social and Behavioral Sciences***, Vol. 45, pp. 284-295, 2012.

[10] Y. Aoki, "Development and practice of teaching materials for studying principles of electromagnetic induction by utilizing sensors equipped in Tablets," ***Japanese Journal of Applied Physics Education***, Vol. 41, No. 2, pp. 63-68, 2017 (in Japanese).

[11] A. Dűnser, L. Walker, H. Horner and D. Bentall, "Creating interactive physics education book with augmented reality," ***Proceedings of the 24th Australian Computer-Human Interaction Conference***, pp. 107-114, 2012.

[12] S. A. Barab, K. E. Hay, M. Barnett and T. Keating, "Virtual Solar System Project: Building understanding through model building," ***J. Res. Sci. Teach.***, Vol. 37, No. 7, pp. 719-756 (2000).

[13] "Augmented Reality for Education," (http://www.augment.com/education/)