British Journal of Educational Technology Vol 44 No 3 2013 E95–E99
doi:10.1111/j.1467-8535.2012.01379.x

Colloquium

Integrating a mobile augmented reality activity to contextualize student learning of a socioscientific issue

Hsin-Yi Chang, Hsin-Kai Wu and Ying-Shao Hsu

Address for correspondence: Dr. Hsin-Yi Chang, Graduate Institute of Science Education, National Kaohsiung Normal University, No. 62, Shenjhong Road, Yanchao District, Kaohsiung 824, Taiwan. Email: hsinyichang@nknucc.nknu.edu.tw

Introduction

Augmented reality (AR) technologies are identified as one of key emerging technologies for education in the next 5 years (Johnson, Levine, Smith & Haywood, 2010). AR takes advantage of virtual objects or information overlaying physical objects or environments, resulting in a mixed reality in which virtual objects and real environments coexist in a meaningful way to augment learning experiences (Arvanitis *et al*, 2007; Dunleavy, Dede & Mitchell, 2008). The recent development of mobile devices makes it possible for mobile AR environments to support outdoor learning enhanced by computer simulations and virtual objects with the focus on real environments (Dunleavy *et al*, 2008). Although more research is needed to investigate pedagogical topics using AR to enhance learning (Rushby, 2012), relatively little has been done regarding how to integrate AR to enhance the learning of socioscientific issues (SSI) that are real world, socially significant, and rooted in science. AR could leverage students' learning of SSI because it could enhance their senses of presence, immediacy and immersion (Bronack, 2011) and situate learning in authentic environments that may in turn result in students making more informed decisions considering all environmental-related factors (Klopfer, 2008; Squire & Klopfer, 2007).

In this study, we focused on a mobile AR activity to contextualize students' learning of an SSI on nuclear energy use and radiation pollution in an online radiation unit we recently developed. SSI are controversial social issues and open-ended problems requiring consideration of scientific evidence, multiple perspectives and solutions (Sadler, 2009; Sadler & Donnelly, 2006). Promoting student learning of SSI has gained much attention in recent research in science education, as the current global society is facing an increasing number of complex issues such as global warming that require decision making informed by scientific evidence and multiperspective reasoning. Moreover, a study found that engaging students in learning an SSI regarding water quality in a virtual environment improved their learning of the science content (Barab, Sadler, Heiselt, Hickey & Zuiker, 2007). In this study, we explore whether an online SSI unit enhanced by AR can improve students' understanding of the science content involved. The main purpose of this study is to demonstrate a work in progress of how we take advantage of mobile AR affordances to design curricular activities that address important science education goals.

Inquiry-based pedagogical design

The mobile AR activity is the first activity of the radiation unit, which situates students in the context of the nuclear accidents at the Fukushima Daiichi Nuclear Power Plant after the 3.11 earthquake in Japan. In this activity, the students' campus is hypothetically a school about 12 km away from the power plant. Eleven dyads of students were provided with Android tablet computers to go to their campus to collect simulated radiation values using the scanning function on the tablet (Figure 1), hypothetically on the first day after the hydrogen gas explosion, from 10 spots on

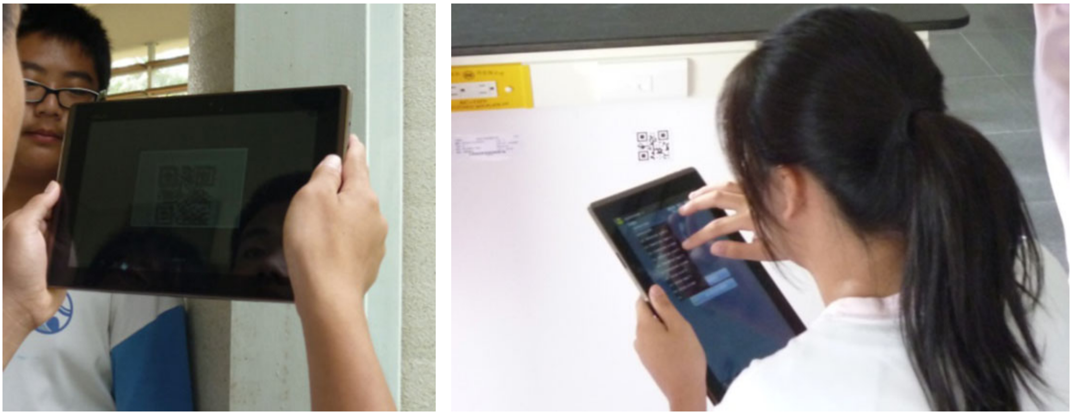

Figure 1: Students using tablet computers with the code scanning function to collect simulated radiation values on campus

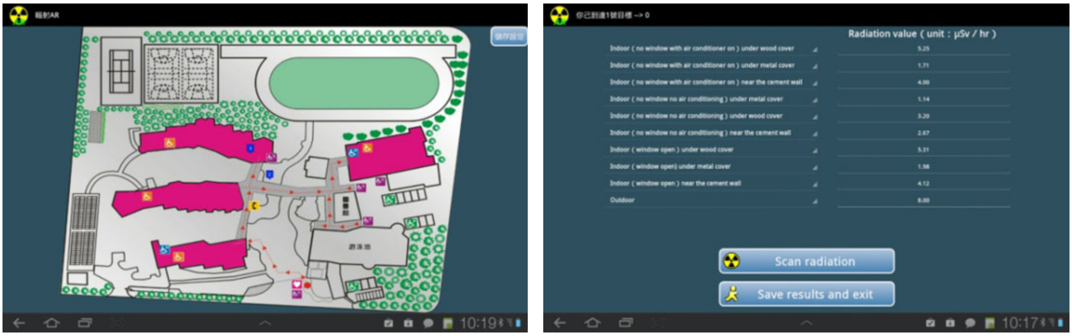

Figure 2: Screenshots of the AR application—a campus map for students to select locations (left); the scan and store interface (right, text originally in Chinese and translated to English for this paper)

campus: three indoor conditions (window open, no window with air conditioning and no window no air conditioning) by three indoor materials (under wood cover, under metal cover and near the cement wall) and one outdoor location. This is a type of mobile AR activity because virtual information (the radiation values) is superimposed on physical environments (locations at the school). We designed the mobile AR activity because it is out of the question to expose students to a real radiation-polluted environment; the AR activity should, however, provide students with a sense of being in a radiation-polluted area as they measure simulated radiation values on campus. We developed a simple application on the tablet computers to automatically store the radiation values as the students scanned the values. The students were required to indicate the condition and location for each value using a drop-down menu (Figure 2). At the end of this AR activity, they were asked to synthesize the radiation values they had collected to inductively reason which material or indoor condition would best help reduce the radiation pollution.

The next three online activities brought the students back to their classroom to use desktop computers with Internet connections. The inquiry and modeling activities scaffold students to learn proper actions to protect themselves from radiation pollution, and science concepts including definitions of radiation, nuclear pollution and the impact of nuclear pollution on ecology through biological diffusion and biomagnification. A decision-making activity about a dilemma regarding remediation for the campus site on which part of the soil was slightly polluted by the radiation elements asked students to select between two proposals, and scaffolded them to consider scientific evidence and multiple perspectives.

Participants and procedure

The study involved 22 ninth-grade students taught by a science teacher at a public middle school in South Taiwan. The students spent 3.5 class periods (45 minutes each) working in dyads to complete the unit. Each individual student took pretests before and posttests after the unit. The pretests and posttests are identical and include two parts. The first contains 13 multiple choice and two constructed-response conceptual items to measure the students' conceptual understanding of the science concepts including definitions of radiation, nuclear pollution, biological diffusion and biomagnification. The conceptual items went through several rounds of revision by science educators to ensure content validity. The Cronbach's α for the conceptual items is 0.77. The second part contains 14 5-point Likert scale items developed and validated by Yang, (2011) to probe the students' attitudes towards nuclear power plants. A higher score of the 14 attitude items indicates that the student is more opposed to the operation of nuclear power plants. The Cronbach's α for the nuclear attitude items is 0.78.

A survey was conducted right after the posttests that required students to indicate their perceptions of six curricular features in the unit in terms of liking and helping learning, including the first mobile AR activity along with the other five features such as the biological diffusion animation and the ecology impact modeling activities in the follow-up inquiry activities.

Results from the implementation

Student perceptions of the mobile AR activity

The average score of the students' perceptions of the mobile AR activity is 7.6, which is above the mean score of the students' perceptions of all features in the unit (7.3). One student indicated, "Using the tablet computers to go outside and actually collect data allows me to get a sense of the unit quickly." Overall, the students' perceptions of this AR activity were positive.

Conceptual understanding, attitude change and the mobile AR activity

In general, the students made significant improvements on the 15 conceptual items from the pretest to the posttest ($t = 2.83$, $p = 0.01$, $n = 22$). This result indicates that an SSI unit enhanced by mobile AR can improve students' learning of the science concepts. To further discern the benefits of the mobile AR activity, we examined correlations between three variables: students' conceptual gains (posttest total scores minus pretest total scores on the conceptual items), nuclear attitude changes (posttest total scores minus pretest total scores on the nuclear attitude items) and perceptions of the mobile AR activity (ranging from 0 to 10, a higher score indicating more positive perceptions in terms of liking and helping).

The relationships among the three variables are summarized in Table 1. The students' conceptual gains are not significantly associated with the students' attitude changes or their perceptions of

Table 1: Correlations between three variables: students' conceptual gains, nuclear attitude changes and perceptions of the mobile AR activity

	Conceptual gain	*Nuclear attitude change*	*Perception of mobile AR*
Conceptual gain	1	–0.18	–0.24
Nuclear attitude change	–0.18	1	0.51*
Perception of AR	–0.24	0.51*	1

Note: *$p < 0.05$.
AR, augmented reality.

the mobile AR activity. However, there is a significantly moderate correlation between students' perceptions of the AR activity and change in nuclear attitudes ($r = 0.51$, $p < 0.05$, $n = 22$). It seems that the more positive attitude towards the mobile AR activity, the more likely the student would be to change to oppose the operation of nuclear power plants.

Conclusions and implications

The study provides a case of how mobile AR can be incorporated into instruction to facilitate learning in an SSI context. The sample size is small, and future studies are needed to generalize the exploratory findings of this study. Nevertheless, with this initial implementation, the results are encouraging because the mobile AR activity was well perceived by the students. The results also indicate a trend in the impact of the mobile AR activity on students' changes of attitudes towards the nuclear power plant issue. Accordingly, we propose two design guidelines to consider and spur conversation.

Combining mobile AR technology, inquiry pedagogy and SSI contexts to address science education goals

The results of this study show that the combination of mobile AR technology and pedagogical inquiry activities in an SSI context is effective in terms of promoting students' understanding of the science content. By creating such a combination, we observe a close alignment of pedagogical goals of SSI learning and technological affordances of mobile AR to focus on real-world issues and physical environments, meanwhile promoting science literacy.

Integrating mobile AR to enhance the situatedness and immediacy of SSI learning

The design of the mobile AR activity in this study builds on the AR affordances of enhancing learners' senses of presence, immediacy and immersion (Bronack, 2011). The mobile AR activity makes it possible for students to be there (presence) in the campus environment to have immersed experiences (immersion) enhanced by the combination of both physical objects and virtual information, aiming to promote a high degree of situatedness and a sense of closeness (immediacy) to the SSI. The situated learning theory suggests that such an environment may influence learners' affective domains such as trust and belief, cognitive domains such as attention and communication, and conceptual domains such as knowledge transfer (Bronack, 2011). We found evidence that the students' changes in attitudes towards the SSI were associated with their perceptions of the AR activity, which is important because the pedagogical goals of SSI stress the need for students to consider affective, moral and ethical aspects, in addition to conceptual aspects, for problem solving and decision making, and the mobile AR activity seems to be able to influence their attitudes. This study only focused on part of the affective and conceptual domains. Future studies need to investigate other important aspects such as moral reasoning in an AR-enhanced SSI learning environment to further discern the benefits of AR for the learning of SSI.

Acknowledgments

This material is based on work supported by National Science Council of Taiwan under Grant No. NSC100-2511-S-017-001 and by the Aim for the Top University Project at the National Taiwan Normal University. We want to thank Wen-Hui Chen for the APP development and Shi-Fang Tzeng for the data collection and analysis.

References

Arvanitis, T. N., Petrou, A., Knight, J. F., Savas, S., Sotiriou, S., Gargalakos, M. *et al* (2007). Human factors and qualitative pedagogical evaluation of a mobile augmented reality system for science education used by learners with physical disabilities. *Personal and Ubiquitous Computing*, *13*, 3, 243–250.

Barab, S. A., Sadler, T., Heiselt, C., Hickey, D. & Zuiker, S. (2007). Relating narrative, inquiry, and inscriptions: a framework for socio-scientific inquiry. *Journal of Science Education and Technology*, *16*, 1, 59–82.

Bronack, S. C. (2011). The role of immersive media in online education. *Journal of Continuing Higher Education*, *59*, 2, 113–117.

Dunleavy, M., Dede, C. & Mitchell, R. (2008). Affordances and limitations of immersive participatory augmented reality simulations for teaching and learning. *Journal of Science Education and Technology*, *18*, 1, 7–22.

Johnson, L. F., Levine, A., Smith, R. S. & Haywood, K. (2010). Key emerging technologies for elementary and secondary education. *Education Digest*, *76*, 1, 36–40.

Klopfer, E. (2008). *Augmented learning: research and design of mobile educational games*. Cambridge, MA: MIT Press.

Rushby, N. (2012). Editorial: an agenda for mobile learning. *British Journal of Educational Technology*, *43*, 3, 355–356.

Sadler, T. D. (2009). Situated learning in science education: socio-scientific issues as contexts for practice. *Studies in Science Education*, *45*, 1, 1–42.

Sadler, T. D. & Donnelly, L. A. (2006). Socioscientific argumentation: the effects of content knowledge and morality. *International Journal of Science Education*, *28*, 12, 1463–1488.

Squire, K. & Klopfer, E. (2007). Augmented reality simulations on handheld computers. *Journal of the Learning Sciences*, *16*, 3, 371–413.

Yang, G.-L. (2011). Exploring high school students' cognition and attitude toward nuclear power plants. *Journal of Educational Forum*, *222*, 38–43. (Article was written in Chinese).