AR-Lab for Learning Science Concepts: Two Case Studies

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Abstract: The purpose of this study was to investigate the effects of augmented reality laboratory on students' learning of science concepts. Two cases were implemented and examined, including learning of convex lens image forming for junior high school students and learning of electrochemistry concepts for senior high school students. The results revealed that (a) the use of augmented reality helped learners achieve better knowledge application performance and (b) students showed positive motivation toward science learning.

Keywords: augmented reality, learning strategy, scaffolding strategy, motivation

1. Introduction

The course of convex lens image forming at junior high school level and the electrochemistry concepts for senior high school students are two abstruse lessons in physics and chemistry; it is due to the reason that students can hardly imagine the form of light and electrochemistry, they have the difficulty constructing their concepts. Learners have plenty of experiences related to light and electrochemistry in daily lives, but light and electrochemistry have features such as untouchability and unobservability, hence students would possibly come up with various personal thoughts and ideas (Enyedy, Danish, Delacruz, & Kumar, 2012). If such abstruse concepts can be presented with virtual animation or gamification by digital technologies, it would be tremendously helpful for students to learn the abstract concepts in science (Tatli & Ayas, 2010).

The technology of augmented reality had been renowned, and its most remarkable feature was the combination of virtuality and reality in which the users could interact with the augmented virtual objects in the real world and attain more real experiences of interactions. Augmented reality combines both features of virtual environment and real world thus it is possible to operate virtual objects in real world (Cuendet, Bonnard, Do-Lenh, & Dillenbourg, 2013). With this feature, virtual information can be added to experimental teaching instruments as to provide more assisted information for the learners during experiment operation (Fiorentino, E-Uva, Gattullo, Debernardis & Monno, 2014). Augmented reality is an innovative method of learning for simulation experimental teaching; in comparison to virtual experiment, learners can self-explore in augmented reality and combine with real world, which is extremely helpful for experiments with abstract concepts. Hence, if learning with the help of augmented reality during hands-on experiment sessions, the learners could gain such experiences from experiments and experience the micro worlds of chemical reactions or physics concepts via augmented reality.

Furthermore, game-based learning can be an inspiring and effective way of learning. Gaming allows learners to solve tasks in virtual scenarios and construct knowledge during the process (Prensky, 2001). The gaming situations allow learners to attain the sense of challenge and feel the excitement during learning. However, in the digital learning environment learners may have difficulty in attaining feelings and experiences of the real world while they are operating the objects virtually, which will lead to the possible inability to connect concepts with reality. Thus, if learning in the real world environment, learners can be helped efficiently construct knowledge (Arslan, Moseley, & Cigdemoglu, 2011). In comparison, augmented reality is situated between real and virtual environments. Augmented reality scans environment or objects in reality via sensor devices and superposes virtual information on scenes of reality by user interface; users interact with real or virtual objects to gain experiences of augmented reality. Billinghurst (2002) suggested that the application of augmented reality in education may have three advantages, including (1) allowing learners to interact instantly with virtual objects under real environment; (2) containing real teaching materials so leaners could operate with instinct; and (3) promoting learning transfer smoothly between virtuality and reality. Therefore, with the expectation to let learners experience interesting experiments and improve comprehension and application by the assistance of digital technologies, the present research employed the augmented reality technology with gamification to (1) investigate the effect of augmented reality on junior high school students' performance and motivation toward the learning of convex lens image forming and (2) examine the effect of augmented reality on senior high school students' performance and motivation in learning electrochemistry concepts.

2. Implementations

2.1 Case 1: Learning of Convex Lens Image Forming—Dragon Fighter

The purpose of *The Dragon Fighter* was developed for learners to learn the Convex Lens Image Forming knowledge by conducting the augmented-reality experiment. As shown in Figure 1, at the first stage, learners had to collect 8 golden balls by going through the prior concepts. As shown in Figure 2, at the second stage, learners need to assemble a firearm by performing the image forming in different object distance. In more details, learners need to fabricate the legendary lighting gun with the procedure of fabrication, including (1) gun barrel making: learners had to move candles and boards to the double focal distance and click on the learning content, (2) gun body making: learners had to move the candles and boards within double focal distance and then click on the learning content, (3) gun pistol making: learners had to move the candles and boards less than the focal distance and then click on the learning content, (4) magazine reloading: learners had to move the candles and boards greater than double focal distance and then click on the learning content, and (5) gun coloring: learners had to move the candles and boards at the focal distance and then click on the learning content. Finally, at the last stage, learners had to apply the learnt knowledge from the previous stages and defeat the evil dragon by applying the image forming steps of convex lens image forming, including (1) draw the light of parallel principal axis, (2) draw the light which travels through doubled focal distance, and (3) draw the light that travels through the mirror center. When learners completed such steps correctly, the legendary lighting gun would appear and the evil dragon fighter will be defeated.

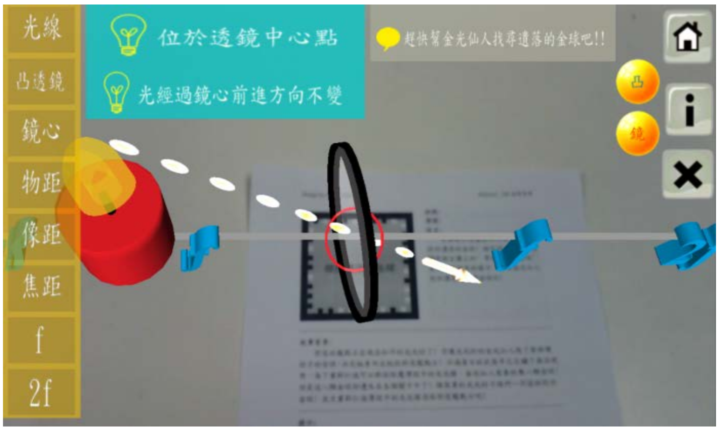

Figure 1. Review prior knowledge and collect golden balls.

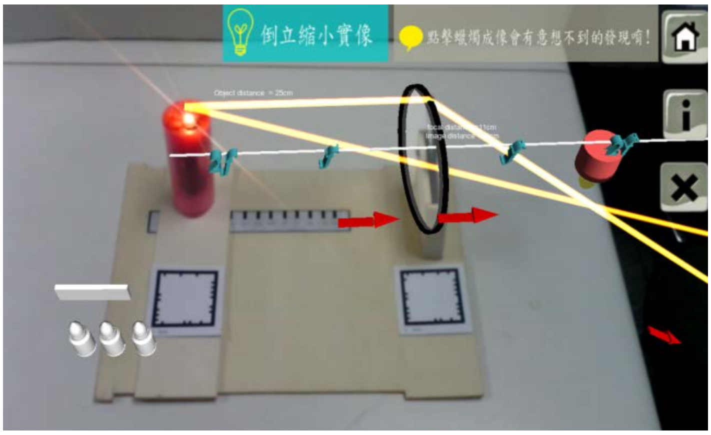

Figure 2. Operate AR experiment to get firepower.

2.2 Case 2: Learning of Electrochemistry Concepts—Manufacturing Iron Man

The AR-laboratory of the *Manufacturing Iron Man* game aimed to help the learners comprehend electrochemical reaction concepts by collecting electrical power for Iron Man as shown in Figure 3 and Figure 4. Two experiments were implemented including (1) the zinc-copper battery and (2) electrolysis and electroplating. Powering up Iron Man was employed as the cumulated feedback structure for learning. Iron man will be powered up gradually when learners conduct correct actions during the experiment. Finally, Iron Man will get enough power to fly and fight against the enemy.

Figure 3. The gaming task challenges the learner to power up Iron Man.

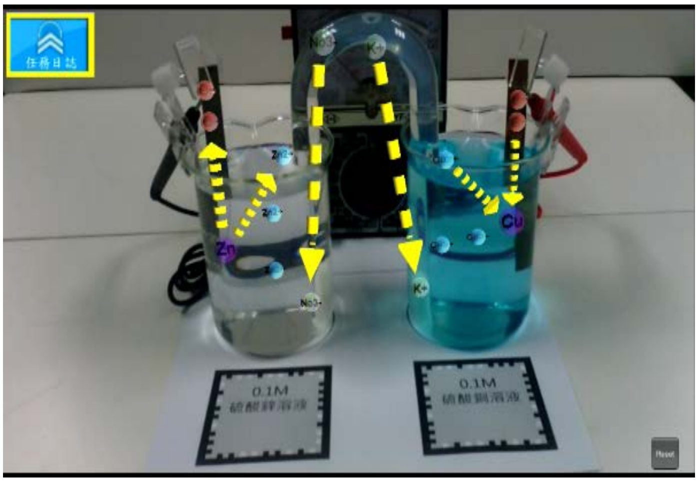

Figure 4. The dynamic motions of electrons were presented using AR.