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The Development of a Simulation to Support Authentic Observation in Precipitation Reaction

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Abstract: In this study, we developed an interactive simulation which can provide authentic observation experience on precipitation reaction by embedding video clips of the actual experiment result. The purpose of this development was to assist students in more authentic observation and modeling on the precipitation reaction. The simulation was built with Flash and ActionScript to runs on wide-ranging devices regardless of operating system. The development process of a simulation through design seminars to reflects the diverse perspectives of teachers and science education experts. Then, we confirmed the validity of the development through the expert evaluation of two experts of science education and four teachers who did not participate in the design seminars. Attempting to introduce new characteristics into science simulation can be attributed to extending the field of simulation design on science education. This study is thought to be useful to come up with a design form suitable for science digital textbooks.

Keywords: Simulation design, Science simulation, Flash, ActionScript, Precipitation reaction.

1. Introduction

Precipitation reaction, as educational experiment in middle school, allows students to understand existing ions in transparent aqueous solution. As the reaction proceeds, a characteristic color of precipitate is observed gradually with naked eye, which helps students with constructing a scientific model of invisible ions. K-12 students who are not accustomed to abstract thinking need an opportunity to observe a continuous process of actual phenomenon in order to construct the ion model effectively (Harrison & Treagust, 2000). However, if the school does not provide laboratory activities due to time, space, or economic constraints, most of students have to rely entirely on textbooks to experience experimental activities indirectly (Park, 2011). Traditional textbooks carry static graphical information, so that they rarely allow students to observe dynamic process of the precipitation reaction (Smetana & Bell, 2012). Furthermore, school culture, which tends to emphasize explicit knowledge for testing, has often emphasized linguistic information, such as color, rather than the phenomenon of precipitation itself (Clark & Mayer, 2016; Wong, Milrad, & Specht, 2015). Emphasis on this kind of well-made scientific knowledge can impress students as a monotonous knowledge to learn, while at the same time hampering higher-order thinking (Jonassen, 2010).

As a candidate to address these issues, simulation can be used as a supplementary material, even in the didactic instruction. A number of science simulations that have been developed so far show dynamic changes of ideal scientific phenomena based mainly on the animation, but the development of a science simulation embedded with video clips has yet to be attempted (Rutten et al., 2012).

In this study, we focused on a design of the science simulation that intend to assist the students in observation as well as modeling that has already attracted attention in precedent literature(Rutten et al., 2012; Smetana & Bell, 2012). Concretely, we developed an interactive simulation that allows student to experience authentic observation on precipitation reaction by embedding video clips of the experiment results. It is built with Flash and ActionScript so as to make it run on various kind of devices regardless of operating system.

2. Methodology

The development process of a simulation was carried out through design seminars, which follows the characteristics of the participatory design introduced by Könings (2014). Design seminars was attended by three chemistry teachers and one professor of chemistry education, in which they provide design comments based on their educational context. Könings (2014) consider that the diverse perspectives of developers, field teachers, and students can reflect by letting them participate in the design process as a designer. But, since students' perspectives are interested-oriented, not professional, we did not consider their participation (Cober et al., 2015). In this study, the researcher take over the role of developer, and held seminars to discuss a design of the simulation prototype with the participants. Then, we evaluated the simulation based on the method of the expert evaluation with two experts of science education and four teachers who did not participate in the design seminars.

In the early stages, the design of the simulation was suggested by the researcher's heuristic knowledge and complemented by participants' comments in the design seminars as well as well-known design principles including the multimedia design principles of Mayer (2005). The simulation developed in this study has two characteristics. First, a video clip of the experiment results taken by the researcher was inserted to express a dynamic process of the precipitation reaction on the reaction plate. At this time, we used a mask function to naturally match square-shaped movie clips with reaction plate graphic objects. The mask function refer to a function that transforms the boundaries of an original object by displaying only the overlapping parts between the original raw object and the freely drawable shape (Figure 1). This minimizes the unnaturalness in layout of screens between different representations (video, animation, graphic).

Figure 1. Transforming the movie shape through mask function

Second, an interactive activity, which contains a scientific model of the invisible ion on precipitation reaction was provided. For example, when mixing solutions in two beakers in a simulation, a dynamic model of the precipitation reaction process is shown in a new beaker (Figure 2 (b)).

3. Results

A development result of the simulation on precipitation reaction is presented in Figure 2. First, a scene example to support authentic observations of precipitation reaction is shown in (a). In the screen, round buttons including arrow are provided for students to drop the reagent interactively asynchronously. In this way, a total of four sets of experiments are provided in this simulation. The nameplate of each aqueous solution is colored as cyan and red to help students differentiate cations and anions from the chemical formula. Second, a scene example to support modeling is shown in (b). It allows learners to build models based on their precedent observation experience in the simulation. If one of the two beakers is pulled and overlapped, the animation of a dynamic model on precipitation reaction is played. In the animation, precipitate is created when two ions involved in the reaction meet each other. The learner can select another precipitate and perform modeling exercises on it. This simulation provides dynamic models of nine precipitate including $CaSO_4$, $BaSO_4$, $CaCO_3$, $BaCO_3$, $AgCl$, PbI_2, CdS, PbS, and CuS. Meanwhile, analysis of the expert ratings is now in progress.

(a) A scene to support authentic observations (b) A scene showing dynamic model of ion

Figure 2. Examples of simulation on precipitation reaction

4. Conclusions

This study presents a case of a science simulation embedded video clips showing practical results in the precipitation reaction. In the development, we focused on a simulation design to provide students with more authentic observation experience than information provided just by the animation. In addition, the simulation incorporates modeling activity based on inherent interactive characteristic of Flash to support deep understanding of presence of invisible ions.

Attempting to introduce new characteristics into science simulation can contribute to extending the field of simulation design on science education. With the recent introduction of classroom technology, simulations are increasingly being included in digital textbooks. This study is thought to be useful to come up with a design form suitable for science digital textbooks.

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