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Communication

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ConfChem Conference on Interactive Visualizations for Chemistry Teaching and Learning: Insights into Molecular Visualization Design

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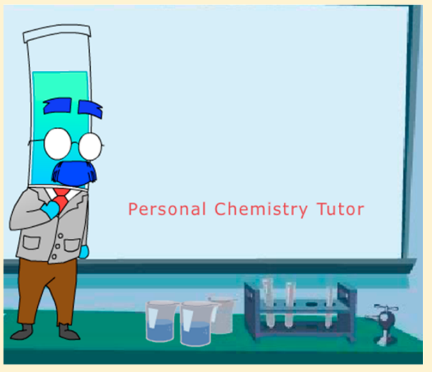
Supporting Information

ABSTRACT: An electronic learning tool (ELT) on precipitation reactions was designed featuring a cartoon chemistry tutor named "Dr. NRG" who directs students through a learning cycle approach to explore the nature of precipitation reactions. Studies done with instructors and students informed the design of atomic level animations that were a main feature of the ELT. Findings from a naturalistic study featuring data from a metacognitive activity embedded in the tool demonstrate the ELT's effectiveness. This communication summarizes a paper that was discussed May 8, 2015 to May 14 2015 during the spring 2015. Discussions following the paper centered on students' misconceptions, instructors' involvement in the development, and pedagogical practices involving animations.



KEYWORDS: *High School/Introductory Chemistry, Internet/Web-Based Learning, Precipitation/Solubility*

In the paper Insights into Molecular Visualization Design, presented as part of the spring 2015 ConfChem online conference,[1] the design process for creating an electronic learning tool (ELT)[2] on precipitation reactions was discussed. The goal of the tool was to find an effective way to teach students about the submicroscopic level of precipitation reactions while drawing connections to the macroscopic and symbolic levels. The framework for the tool was based on a three-step learning cycle and consisted of these:

1. Exploration: Students were asked to ponder why it was that when two aqueous salt solutions were mixed, sometimes they reacted and a precipitate was formed, but sometimes two solutions were mixed and nothing seemed to happen.
2. Concept Development: Animations of the submicroscopic level were presented that consisted of a complex version of the reaction between aqueous silver nitrate and aqueous sodium chloride as well as a segmented view of the same reaction with additional animations to account for the nature of hydration spheres and the formation of the precipitate. A segmented set of animations, in which no reaction occurred, was also presented. In addition, cartoon tutorials featuring Dr. NRG, a small test tube that comes to life, were incorporated to teach the connection to equations that symbolically represent the reaction event. At the end of the video, a few interactive assessment items were presented to allow students to test their understanding.
3. Concept Application: In this section, students were asked to solve the puzzle of five mystery solutions, whose labels were unavailable, but with their distinctive precipitate reaction pattern, the chemist in training could identify the solutions from a list of potential solutions. Students were also tasked with constructing equations and atomic level pictures of the reactions.

To inform the design of the atomic level representations that were the heart of the ELT, 11 chemistry instructors (7 males and 4 females of diverse ethnicity) all with doctorate degrees in chemistry disciplines were interviewed to examine how they segmented their understanding of precipitation reactions to teach first year, General Chemistry students. The instructors were asked to draw their submicroscopic level understanding of three molecular equations as they would expect their best students to draw them. The findings indicated that instructors drew three segments to convey changes in time as the reaction progressed from reactants to products. The first segment consisted of events that occurred prior to the start of a reaction. The second segment illustrated the dynamic nature of the reaction with collisions between ions. The third and final segment illustrated the nature of the species at the conclusion of the reaction.

With the assistance of San José State University (SJSU) students enrolled in the Animation and Illustration Bachelor of Fine Arts Program, I designed a group of animations for students enrolled in introductory chemistry courses (secondary or tertiary). The animations were designed to be consistent with the way that the instructors depicted the reaction events as informed by the initial study. The animations were placed in

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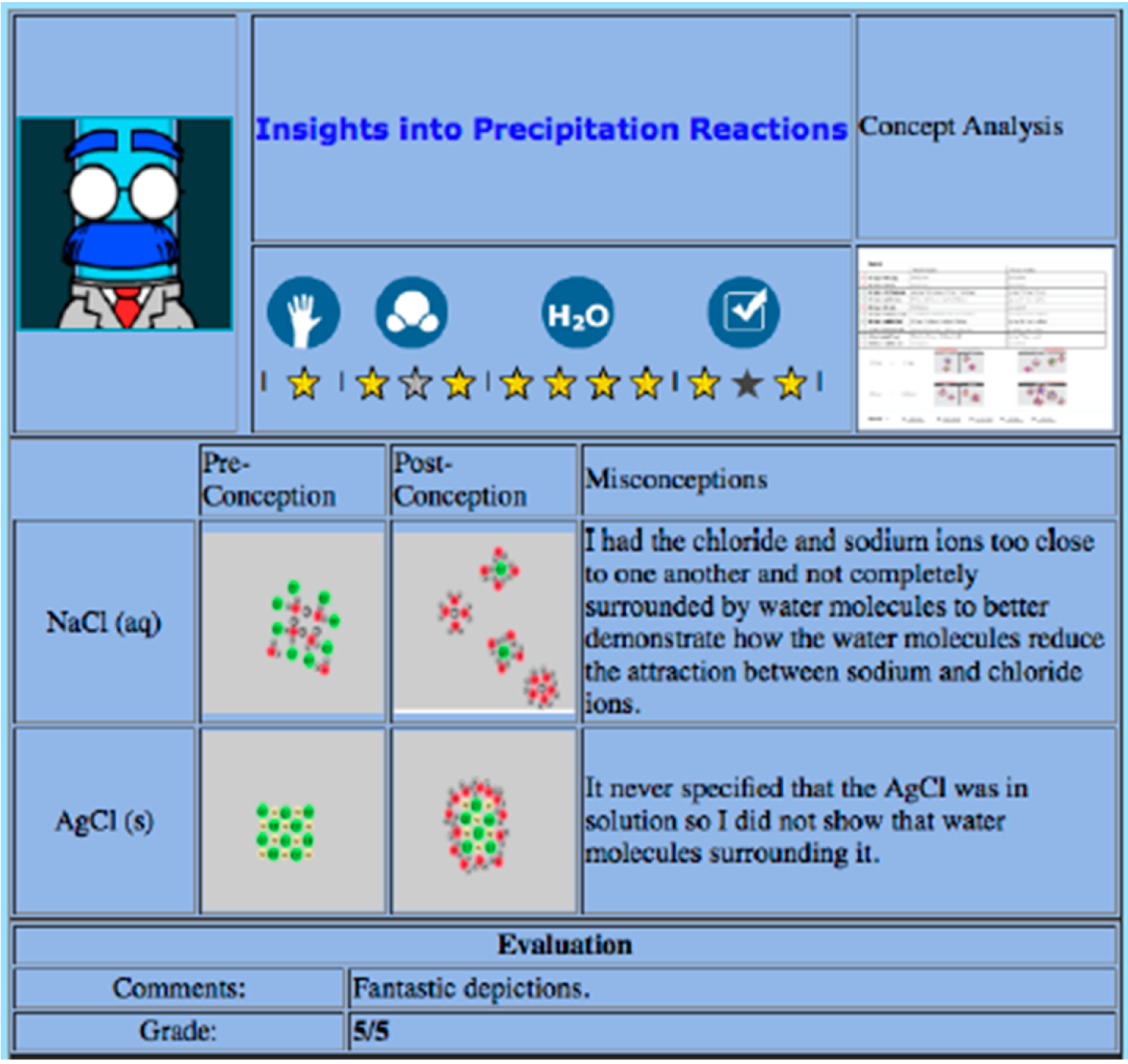

Figure 1. A screen shot of the feedback form provided to a student that shows the student's pre-conception pictures made prior to viewing animations and post-conception pictures and misconception descriptions made after completing the Concept Development section of the ELT.

the Concept Development section of the ELT. This section was constructed with the caveat that before the students could access the animations, they were required to first construct their atomic level conceptions (pre-conceptions) of one aqueous reactant solution and the solid precipitate. Students constructed their pictures with click-and-drag tools that provided them with both conventional and unconventional options for portraying their understanding. Upon completion of the Concept Development section, students were asked to once again construct their understanding of the same reactant solution and precipitate using the same click-and-drag tools. In addition to the post-conception or *after* pictures, students were also asked to type a short explanation identifying the misconceptions they initially had and how they repaired them (Figure 1).

To demonstrate the effectiveness of the ELT, results were shared from a naturalistic study involving 19 introductory chemistry lab sections, consisting of approximately 500 total students, who were assigned to complete the ELT on precipitation as a prelab exercise. In general, the findings revealed that students incorporated a greater amount of key features in their *after* pictures, and they demonstrated fewer misconceptions in comparison to their preanimation conceptions.

■ DISCUSSION

Here a summary of the main topics from the discussion of the ConfChem paper is provided. Some of the readers wanted to better understand participant instructors' perspectives as they engaged in the picture construction task and their logic when they simplified their pictures. In general, it was noted that instructors were able to maintain their focus to design their drawn explanations with the student perspective in mind, but it was not unusual for them to approach it from their teaching experience too. In constructing their drawings, most considered the features they felt were important to emphasize and they tried to explicitly represent those features in their drawings. Many instructors had a strong symbolic emphasis in their pictures.

Additional discussion items centered on why students held misconceptions regarding "ion pairs" and some wanted to know how the author used animations in her teaching practice. As shown in the Supporting Information, some of the discussants shared their understanding and preference for teaching about

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aqueous ionic solutions, how they developed a context for teaching with animations, and activities that they employed in their teaching practice.

■ ASSOCIATED CONTENT

Ⓢ Supporting Information

The Supporting Information is available on the ACS Publications website at DOI: 10.1021/acs.jchemed.5b00556.

Full text of the original paper and associated discussions from the ConfChem conference, as well as the activity described (PDF)

■ AUTHOR INFORMATION

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Notes

The authors declare no competing financial interest.

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■ REFERENCES

(1) American Chemical Society Division of Chemical Education Committee on Computers in Chemical Education. 2015 Spring ConfChem: Interactive Visualizations for Chemistry Teaching and Learning. http://confchem.ccce.divched.org/2015SpringConfChem (accessed Dec 2015).

(2) The Electronic Learning Tool is available online at http://chemteam.net (accessed Dec 2015). Please e-mail Resa Kelly (resa.kelly@sjsu.edu) for additional access to the ELT website.

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