Chemation: A Handheld Chemistry Modeling and Animation Tool

Lisa Ann Scott, Robert Zimmerman, Hsin-Yi Chang, Mary Heitzman, Joseph Krajcik, Kate Lynch McNeill, Chris Quintana and Elliot Soloway
Center for Highly Interactive Computing in Education
University of Michigan
610 E. University, 4031 SEB
Ann Arbor, MI 48109 USA
734-647-2975
lisscott@umich.edu

ABSTRACT
Chemation, a simple 2-D modeling and animation tool for handhelds (e.g., PalmOS computers), was developed to help teach important chemistry concepts, such as chemical reaction, conservation of mass, and the particulate nature of matter (as specified in national standards). Users build 2-D molecular models of substances and then, through a process of copying and modifying the model, create flipbook-style animations to illustrate various processes. Chemation is currently being piloted by teachers using a standards-based, inquiry-oriented 7th grade chemistry curriculum. The tool is intended to be an alternative or a supplement to current hands-on activities in which students build physical (ball-and-stick) models to represent various chemical phenomena. In this demonstration, we will show the basic functions of Chemation highlighting its important features—modeling and animation of chemical processes on a handheld tool. We will also show example student models of various chemical processes.

Keywords
Modeling, animation, handheld, chemistry

INTRODUCTION
National standards call for students to develop both deep understandings of science concepts as well as the ability to understand and do scientific inquiry [2, 5]. Specifically, the chemistry standards specify chemical reaction, conservation of mass, and the particulate nature of matter as target content learning goals for middle school students. Research has shown that students often confuse physical changes (e.g., mixing or boiling) and chemical changes [1]. They do not understand that in chemical reactions, the atoms and molecules comprising substances recombine (i.e., break bonds and make new ones) to create new molecules and thus new substances.

The Center for Highly Interactive Computing in Education (hi-ce) has developed a standards-based, inquiry-oriented chemistry curriculum [4] in response to the need for science curricula that directly address important learning goals and known student difficulties [3]. The unit, "How Can I Make New Stuff From Old Stuff?" contextualizes the targeted chemistry concepts and scientific inquiry skills in real-world student experiences. Students conduct investigations and engage with real-world phenomena to help them develop an understanding of chemistry concepts. Chemation is a PalmOS-based application created as a supplemental tool to be used with this curriculum.

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CURRICULUM ACTIVITIES
There are a number of activities in the curriculum that focus on the particulate nature of matter. Students build physical (ball-and-stick) models to represent substances (which are made of one type of atom or molecule) and also to represent mixtures (which are made of more than one type of atom or molecule).

Physical models are also used to demonstrate the behavior of atoms and molecules in various chemical processes. In a chemical reaction, the atoms that make up the molecules of the original substances combine in new ways to form new molecules. Chemical reactions are contrasted with physical changes (e.g., mixing and boiling) where there is no recombination of atoms, and the same molecules exist before and after the process.

Finally, students use their knowledge of chemical reactions in combination with physical models to help explain why mass is conserved in chemical reactions. The models help to demonstrate that the number and type of atoms stays the same no matter how they are rearranged, and therefore the total mass stays the same.

CHEMATION
Where physical models are often used, Chemation can be used as an alternate or supplemental activity. Chemation allows middle school students to build 2-D models of atoms or molecules. Students can then model chemical processes by creating flipbook-style animations.

Chemation has three types of objects: atoms (or particles), links, and labels. Objects are created using the toolbar shown in Figure 1. When the atom tool is selected, a

palette of atoms appears. Tapping the stylus on the screen creates an atom. Some atoms have element symbols on them and some do not. Those without element symbols can be used to represent other elements or even whole molecules. The link tool is used to connect two atoms. Links indicate the presence of a bond between two atoms, but are called links because they do not attempt to represent the type of bond (e.g., single or double). Atoms are linked by tapping sequentially on the atoms being connected. The text tool is used to create labels, which are free-form text boxes. The use of labels allows students to document the models they build. Students can easily delete atoms, links or labels by simply drawing a line through them.

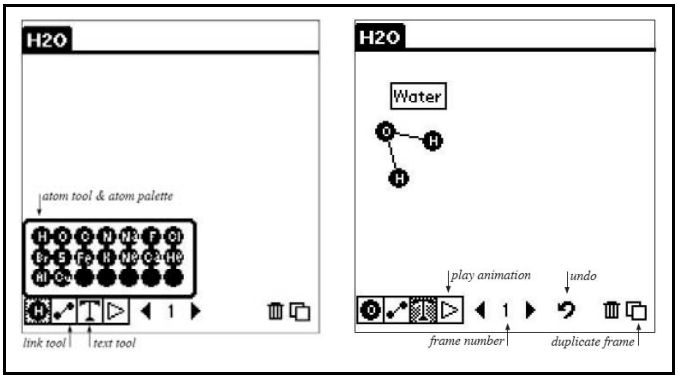

Figure 1: Toolbar and sample model

Flipbook-style animations are created through a simple process of copying and modifying frames. The toolbar in Figure 1 indicates that the water molecule is in frame 1. This frame can be copied by clicking on the "duplicate frame" button at the bottom right of the screen. The copy becomes frame 2 and can be slightly modified by adding, deleting or moving atoms and adding or deleting links. Continuing this process of copying and modifying frames creates a series of frames that can then be played back by clicking the "Play" button next to the label tool.

Having used a learner-centered design approach [6] to develop Chemation, we highlight three main aspects of Chemation that support student learning of a notoriously difficult concept: (1) Modeling: The atom palette and link tool simplify the model-creation process so that students' attention may be focused on conceptual understanding of what is being modeled; (2) Animation: The animation feature provides the most important support for student learning, allowing students to articulate and examine the chemical *process* being modeled rather than merely the beginning and end points; (3) Portability: Due to the pervasive nature of handhelds, students take ownership of their models and can review, reflect on or modify their models at any time.

DEMONSTRATING STUDENT ANIMATIONS

In this demo, we will show the major features of Chemation and use the tool to illustrate some of the ways students have used Chemation in the curriculum as they studied substances, mixtures, and chemical reactions.

• Static and animated models of mixtures. An early lesson in the curriculum contrasts substances and mixtures. The focus of this lesson is not on process but instead on the difference in molecular make-up of substances and mixtures. Not surprisingly, many students built static models and did not make use of Chemation's animation capabilities. On the other hand, some students were very creative and found an interesting way to incorporate animation into their model of a mixture. One student's mixture animation showed a urea molecule dropping into a pool of water molecules and then mixing with them.

• Use of unlabeled atoms to represent molecules. Some students built models of boiling in which unlabeled atoms represented water molecules. The water molecules then moved farther apart to demonstrate the phase change.

• Quality of animations. Some animations do not convey process as clearly as others. Some students created very smooth animations by making many frames with very small modifications from frame to frame. Other students used fewer frames and made larger changes from frame to frame. This resulted in jerky animations which do not convey the process as clearly as the smoother animations. Other students did not use the "duplicate frame" tool. Their animations seem to flash as different atoms and molecules appear on each frame.

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