Chapter 8

Simulations in Chemistry for Conceptual Understanding and Assessment of Student Knowledge

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ABSTRACT

Simulations are dynamic resources that have been found useful for communicating abstract fundamental ideas such as stoichiometry and several other concepts. In this chapter the authors present their recent work on designing and implementing an interactive simulation called Combustion Lab based on reaction stoichiometry - a topic that has continually been a challenge for chemistry learners. Several researchers have reported persistent student misconceptions in stoichiometry. In order to address this challenge, a novel computer simulation was developed to assess student understandings of stoichiometry based on student problem solving performance, and also to promote student conceptual understanding. The Combustion lab was particularly focused on the stoichiometry of these reactions, problem solving, and the relevance of stoichiometry for its everyday applications. Results of this sequential exploratory study show that the simulation was effective in revealing student understanding and student treatment of stoichiometry problems based on analysis of various data collected.

DOI: 10.4018/978-1-5225-2528-8.ch008

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INTRODUCTION

The use of interactive simulations in chemistry has seen a rapid surge in the past decade. Simulations are digital environments that allow users to interact with models of various concepts and processes. A simulation uses a mathematical or a logical model to illustrate real world phenomenon with a goal of providing opportunity to students to understand the underlying concept or scientific model (Suits & Sanger, 2013). Prior researchers have found simulations to be effective in helping students visualize relative motion and in improving problem solving and critical thinking by supplementing sensory experiences of learners (Falvo, 2008; Gerjets & Hesse, 2004; Stieff & Wilensky, 2003).

Simulations have been found effective in engaging students; improving student exam scores and their representational competence, and fostering student understanding of specific concepts such as the particulate nature of matter and electrochemistry (Barak 2013; Falvo, Urban, & Suits, 2011). Simulations allow students to explore phenomena and their representations while manipulating variables. Simulations thus provide a certain degree of control to learners through their interactive features such as play and pause buttons, adjusting variables such as mass, volume etc. using buttons and sliders, and stop, review, and exit functions. Some researchers have focused on design features of simulations. These researchers suggest that simulation developers should design simulations that are simple to use; display a balance of information, have audio and visual components in design; allow user control; reduce extraneous cognitive load on learners; and accurately portray the concepts and processes in chemistry. Simulation designers should also consider the prior knowledge of learners, which plays an important role in student use of simulations (Landriscina, 2013; Plass, Homer, & Hayward, 2009).

Despite numerous studies on simulations in chemistry, there is a lack of evidence of simulations being effective in assessing student understanding based on problem solving abilities of students with specific problems incorporated within the simulation. This chapter highlights the development and implementation of a stoichiometry based simulation called “Simulation Lab” and its implementation in organic chemistry laboratory with students taking first semester of a two-semester sequence of organic chemistry laboratory course in a mid-western university. The goal of simulation was to assess student understanding based on their performance on stoichiometry problems. The study also determined student approach to problem solving based on qualitative analysis of simulation lab data and student - written laboratory reports.
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