SiMSAM: An Integrated Toolkit to Bridge Student, Scientific, and Mathematical Ideas Using Computational Media

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Abstract: We are developing SiMSAM (**Si**mulation, **M**easurement, and **S**top **A**ction **M**otion): an integrated toolkit for middle school science. SiMSAM will enable students to construct animations, 'crop' images from those animations to use as programmable simulation objects, measure patterns in simulations, and share creations. We present (1) analyses of video data from a pilot design studio focusing on patterns in students' representational choices, scientific engagement, and attention to causal mechanism; and (2) prototypes of SiMSAM for feedback.

Motivation and Objectives

There are calls for K-8 science instruction to build on students' existing ideas about the world; involve students in proposing and refining models and explanations; and engage students with the tools and discourse of STEM professionals (NRC, 2012). Increasingly, computation and simulation are the tools scientists use to explore and communicate complex ideas and data (Chandrasekharan et al., 2012; NRC, 2010).

We are developing SiMSAM, a web-based toolkit to engage middle-school students in a technology mediated modeling cycle: including theorizing, model construction, testing, sharing, and iterative refinement. SiMSAM will enable students to (1) build stop motion animations of kinetic molecular phenomena using paper drawings or physical props, (2) 'crop' images from those animations and program them using domain specific visual manipulations to create a simulation of the modeled phenomenon, and (3) analyze the simulation using measurement and graphing tools. It will also (4) support networked sharing for students to critique, refine, and build upon their classmates' work.

SiMSAM is informed by Constructionist (Papert, 1980) and representationally mediated (Kaput, 1998) theories of learning, and is based on the premise that students need a supportive continuum from openly discussing ideas in the classroom to mobilizing those ideas toward constructing computational models. It builds on prior simulation and animation tools that have been shown to support student learning and engagement around molecular theory (Chang, Quintana, & Krajcik, 2010; Tinker & Xie, 2008; Wilensky, 2003). We merge these approaches so that at all levels, *students' ideas should be the substance of construction*: they create or select their own objects (or those of their classmates), define their own rules to govern object interactions, and define their own measures to explore simulation outcomes.

Research Questions

We are using SiMSAM prototypes and existing tools as a design-based research environment (Cobb et al., 2003) to explore how students express and translate ideas across different multi-modal discourses. Data yielded will speak to two open questions:

RQ1. To what extent can SiMSAM support a "continuum" in which students express and maintain ownership over their ideas across different representational media?

RQ2. Which aspects of students' understanding of kinetic molecular theory persist, shift, appear or disappear as students construct models across different representational media?

Data and Preliminary Results

In Fall 2012 we conducted a "design studio" (Druin, 2002) with five sixth-grade girls using existing animation and simulation tools (SAM Animation and StageCast Creator). We held a total of four sessions in which we asked participants to theorize and test one another's ideas about how an orange on one end of a room can be smelled at the other (Schwarz et al, 2009).

In Day 1 we discussed smell diffusion in a group, and asked students to draw models and create SAM animations of smell diffusion. In Day 2, we revisited the girls' animations, and introduced them to StageCast Creator. In Day 3, the girls continued to work on their simulations, and in Day 4 revised their simulations and began to measure the resulting patterns generated by counting the number of smell particles (what they called "Oogtum") reaching humans at different places in the simulated world.

We analyzed video from all four workshop days in five minute segments, using established frameworks to code each segment for evidence of modeling practices, scientific inquiry practices, facilitator moves, reasoning about mechanism, and student ideas related to smell and particulate models of matter. We present patterns in the ideas and practices that emerged, persisted, or waned as students expressed or tested their models in different media.

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