International Society of the Learning Sciences

Strategies towards Designing for Sustained Engagement in Computational Modeling in Science Classrooms

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Abstract: This poster presents emerging strategies for engaging students in extended investigations with computational modeling. Drawing on the literature on modeling and co-design with teachers over a year, we present 3 strategies and describe how they support student sense making and learning: 1. Curricular coherence and consistency; 2. Integrating multiple forms of data and modeling while foregrounding uncertainty; and, 3. Enabling unpacking blocks as a way to balance between ease of use and expressivity in modeling.

Introduction & Background

There is considerable research exploring how, through design and pedagogy, educators can lower the barrier to computational modeling. Modeling environments that make use of accessible media like domain-specific toolkits (e.g., Kahn, 2007; Wilkerson, Wagh & Wilensky, 2017) ease the technical aspects of programming, whilst pedagogical approaches such as bifocal modeling (Blikstein et al., 2016) support conceptual aspects of computational modeling. Thus far, however, much of this work has involved one-time or short exposures to computational modeling through specific projects or activities. Less is known about how to make computational modeling a *sustained* practice in classrooms.

This poster presents a design-based research study that seeks to design for and study the role of sustained engagement in computational modeling in middle school science classrooms. We build on the broader modeling literature in which extended investigations with modeling and iterative refinement are part of what students do (e.g., Lehrer & Schauble, 2012) to identify three strategies: 1. Coherence and consistency: By "coherence", we mean repeatedly revisiting a small set of disciplinary core ideas from multiple perspectives to pursue extended investigations (Lehrer & Schauble, 2012). Prior work has shown that linking multiple units with a core conceptual idea helps by providing a broad range of contexts to make sense of a conceptual idea (Fortus et al., 2015); 2. Integrating data and modeling: Physical experimentation is a common practice in many middle school science classrooms. We leverage this practice by juxtaposing data and modeling to highlight--rather than dismiss--discrepancies between models and data, bringing noise, uncertainty, and intrinsic differences between them (Blikstein et al., 2016; Gouvea & Wagh, 2018), and, 3. "Unpacking" blocks: We propose the construct of *unpacking* blocks to balance between ease of usability and expressiveness in domain-specific modeling environments.

Design methodology

Our aim in this poster is to present design strategies that have emerged as important through teacher co-design for engaging students in extended investigations through computational modeling in science class. We iteratively refined and modified the A2S modeling environment and unit design through monthly co-design sessions with 4 middle school science teachers over 1 year and an additional 4 teachers over 6 months, a 3-day intensive co-design workshop with 8 teachers, and observations and design reflections from 224 students engaging with the units in science class. Out of 4 target units, we have developed and implemented 2 curricular units.

Findings: Design strategies for sustained computational modeling

Below, we present the design manifestation of each of the three design strategies.

Coherence & consistency

Based on teacher feedback, we use diffusion or the movement of particles from high to low concentration as a disciplinary core idea in the first two units. In one unit, students examine how diffusion impacts ink spread in hot and cold water, and in a second unit, they examine how it impacts the spread of wildfire smoke. To underscore that the same disciplinary idea relates to both units, the library of blocks for particle behaviors the two units in the modeling environment considerably overlap. For instance, random movement ("move"), particle collisions ("bounce off") and behaviors representing student ideas such as combine ("attach") or disappear ("erase") are present in both block libraries. In the poster, we will present whether and how students attend to, make sense of and link identical behaviors in these two different phenomena.

Integrating data and modeling

We aim to build uncertainty into student investigations through data to create resistances for students to consider, tackle and possibly resolve (Manz, 2015). The A2S modeling environment enables students to link modeling with real-world data. In the first unit, students build and compare their models with a video of an experiment they conduct in class. In the second unit, they build and compare models with satellite videos of smoke spread from California wildfires. In the poster, we will present how students engage in integrated data and modeling practices to make sense of target phenomena.

Unpacking blocks: Balancing ease of use and computational expressivity

The goal of "unpacking" blocks is to enable students to be able to open up a defined block to view and modify its definition. The idea is for students to be able to view and redefine how a domain-specific behavior such as "interact" or "move" is encoded and enacted. For instance, students can define interaction between two particles as them bouncing off of each other or combining together or one particle changing another particle's color. Conceptually, this is a place for students to test their theories about agent level mechanisms, and how they can impact the model. In the poster, we will present whether and how unpacking blocks provides a way for students to computationally express more sophisticated conceptual ideas in code.

Discussion

This poster contributes to the literature on computational modeling by examining design strategies that can support students and teachers in classrooms to engage in extended investigations with computational modeling. In the poster presentation, we will present each of these strategies and how they enable students to engage in sustained modeling investigations of two different phenomena. We will also reflect on some of the challenges in designing for extended investigations in computational modeling.

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Acknowledgments

This material is based upon work supported by the National Science Foundation under Grant No. 2010413. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.