"It Must Include Rules": Middle School Students' Computational Thinking with Computer Models in Science

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When middle school students encounter computer models of science phenomena in science class, how do they think those computer models work? Computer models operationalize real-world behaviors of selected variables, and can simulate interactions between the modeled elements through programmed instructions. This study explores how middle school students think about the high-level semantic meaning of those instructions, which we term *rules*. To investigate this aspect of students' computational thinking, we developed the Computational Modeling Inventory and administered it to 253 7th grade students. The Inventory included three computer models that students interacted with during the assessment. In our sample, 99% of students identified at least one key rule underlying a model, but only 14% identified all key rules; 65% believed that model rules can contradict; and 98% could not distinguish between emergent patterns and behaviors that directly resulted from model rules. Despite these misconceptions, compared to the "typical" questions about the science content alone, questions about model rules elicited deeper science thinking, with 2–10 times more responses including reasoning about scientific mechanisms. These results suggest that incorporating computational thinking instruction into middle school science courses might yield deeper learning and more precise assessments around scientific models.

CCS Concepts: • **Social and professional topics → Computational thinking**; **Student assessment**; **K-12 education;**

Additional Key Words and Phrases: Middle school science; computer models; computer models in science

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1 INTRODUCTION

Designers of educational technology often present complex science ideas through interactive models and simulations (e.g., the University of Colorado's PhET [1] and the Concord Consortium's Molecular Workbench [5]). Dynamic models of scientific phenomena have gained importance in

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