Making Sense of Earth's Climate Using Iterative Algebra

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Differential equations are fundamental to many models of dynamic systems. Earth's climate, for example, is a dynamic system often modeled using differential equations (Kaper & Engler, 2013). Differential equations thus provide a promising avenue to incorporate pressing topics such as Earth's shifting climate into the mathematics classroom; however, not all students study differential equations, which necessitates an alternative method to introduce students to mathematical relationships governing a complex system's evolution (Bressoud, 2015; Bressoud, 2021). One method proposed to teach students ideas similar to differential equations without the use of calculus is through *iterative algebra* (Coles, 2013). Using an iterative algebra approach, students are given an initial state and an equation that defines how the system changes for each future timestep. The change is always based on the system's current state and is repeated iteratively to model how a system changes over time.

Despite the potential of iterative algebra in mathematics classrooms, few studies have determined how students can understand dynamic systems using iterative algebra. Our study addresses this gap in research through investigating how students—who mostly do not have a calculus background—make sense of the mathematics and science behind a climate system using iterative algebra. In particular, we ask, *How do students make sense of the mathematics and science of equations modeling aspects of Earth's climate?* To answer this question, we studied students *sensemaking*—how individuals make meaning of new situations based on prior experience and knowledge (Odden & Russ, 2019). We used an even more specific framework, the Sci-Math sensemaking framework (Zhao & Schuchardt, 2021), as a tool to analyze the types of mathematics and science sensemaking students engaged in while working with a mathematical model of climate.

In a college algebra classroom in a large Midwestern university, students were tasked to develop and interpret recursive equations (i.e., engage with iterative algebra) representing the dynamics of the North Atlantic Current. The activity took place across three consecutive 75-minute class sessions of college algebra. We collected audio recordings and written responses from each participating group. Using the Sci-Math Sensemaking, the sensemaking processes of three different groups of students (each composed of 2-3 students) were studied as they worked on the mathematical climate model activity.

Students engaged in an array of mathematics and science sensemaking types. We found that students understood variables and rates of change as mathematical and scientific constructs. For example, students recognized that certain parts of their equations represented change, either by discussing the quantity or direction of change (mathematics sensemaking) or by describing the science context of the change (science sensemaking, e.g., "This part of the equation represents the temperature of the water decreasing over time"). Furthermore, when developing equations, students often began by making sense of the science context, completing a series of calculations, followed by generalizing their calculations in equation form. These results suggest that students, with primarily no calculus background, can engage in interdisciplinary sensemaking of a dynamic system. This provides promise for teaching more students dynamic systems through iterative algebra.

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