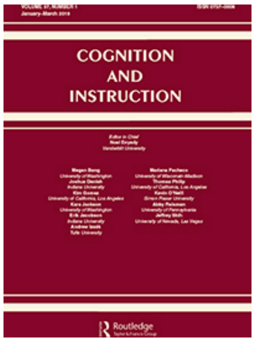

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Coordinating between Graphs and Science Concepts: Density and Buoyancy

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ABSTRACT
Graphs illustrating complex scientific relationships require students to integrate multiple concepts and visual features into a coherent understanding. We investigate ways to support students in integrating their understanding of density concepts through a graph that is linked to a simulation depicting the relationship between mass, volume, and density. We randomly assigned 325 8th-grade students to 1 of 2 graphing activities. In the *analyze* condition, students plotted a set of data points selected to help clarify the relationship between mass, volume, and buoyancy, and then interacted with a guided simulation to improve their plotting accuracy. In the *generate* condition, students chose their own data points, and then interacted with a guided simulation to test and revise their choices. We found that, although *analyze* participants were more likely to construct accurate graphs, *generate* participants were more likely to develop a coherent understanding of density and buoyancy. Analyses of process data and interviews suggest that *generate* participants grappled with the mass-volume ratio by deliberately testing points and identifying patterns as they updated their understanding of science concepts. In contrast, *analyze* participants displayed less deliberate exploration of the graph space. We discuss how activities that integrate graph interpretation and concept refinement can deepen science learning.

Graphical representations support coordination between theory and evidence, thereby facilitating discovery and understanding of scientific concepts (Kuhn, Schauble, & Garcia-Mila, 1992). Scientists often use graphs to reveal critical relationships represented as spatial patterns (Kozma, Chin, Russell, & Marx, 2000). Ideally, students would use graphs to learn similar relationships; however, the complex visual representations inherent in graphs often confuse students. Although instructional research (e.g., McNeill & Krajcik, 2009; J. Roschelle et al., 2010) and recent standards (e.g., NGSS Lead States, 2013) advocate use of data-centered graph activities in inquiry instruction, students often lack sufficient experience to take advantage of graphs (Leinhardt, Zaslavsky, & Stein, 1990; Shah & Hoeffner, 2002). In this study, we investigate two approaches to structuring graphing activities designed to help students recognize and interpret complex relationships to understand a scientific concept.

Overview

Advantages of graphs

Graphs can reveal how multiple variables interact in ways that are difficult to uncover in case-by-case observations. For example, the parameter space graph (Lee, Pallant, Tinker, & Horwitz, 2014) displayed in Figure 1, captures the relationship between mass, volume, and buoyancy. The graph shows that although mass plays a role in determining whether an object sinks or floats, it

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