Chapter 9
Disciplinarily-Integrated Games:
Generalizing Across Domains and Model Types

Douglas B Clark
Vanderbilt University, USA

Pratim Sengupta
University of Calgary, Canada

Satyugjit Virk
Vanderbilt University, USA

ABSTRACT

Clark, Sengupta, Brady, Martinez-Garza, and Killingsworth (2015) and Sengupta and Clark (submitted) propose disciplinarily-integrated games as a generalizable template for supporting students in interpreting, manipulating, and translating across phenomenological and formal representations in support of a Science as Practice perspective (Pickering, 1995; Lehrer & Schauble, 2006). To explore the generalizability of disciplinarily-integrated games, this chapter proposes other hypothetical examples of disciplinarily-integrated games in physics, biology, chemistry, and the social sciences. We explore disciplinarily-integrated games in three categories, beginning with the category involving the nearest and simplest transfer of the template and extending to the category involving the furthest and most complex transfer: (1) time-series analyses with Cartesian formal representations, (2) constraint-system analyses with Cartesian formal representations, and (3) other model types and non-Cartesian formal representations. We close with the discussion of the implications of this generalizability.

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INTRODUCTION

Clark, Sengupta, Brady, Martinez-Garza, and Killingsworth (2015) outline an approach for leveraging digital games as a medium to support the development of scientific modeling in K-12 classrooms based on the Science as Practice perspective (Pickering, 1995; Lehrer & Schauble, 2006). Clark et al. name this approach disciplinary integration and outline its development though a program of iterative research on student learning. Sengupta and Clark (submitted) extend the theoretical framing of disciplinarily-integrated games in terms of materiality within the classroom and the iterative design of multiple complementary symbolic inscriptional systems.

Clark et al. (2015) and Sengupta and Clark (submitted) propose that disciplinarily-integrated games represent a highly generalizable genre. To explore this claim of generalizability, the current chapter proposes other hypothetical examples of disciplinarily-integrated games (which we will refer to as DIGs for brevity) in physics, biology, chemistry, and the social sciences. We explore DIGs in three categories, beginning with model types and modeling strategies involving the nearest and simplest transfer of the DIG template and extending to those involving the furthest and most complex transfer:

1. Time-series analyses with Cartesian formal representations,
2. Constraint-system analyses with Cartesian formal representations, and
3. Other model types and non-Cartesian formal representations. We close with the discussion of the implications of this generalizability.

BACKGROUND

The Science as Practice (or SaP) perspective (Pickering, 1995; Lehrer & Schauble, 2006a, 2006b; Duschl et al., 2007) argues that the development of scientific concepts is deeply intertwined with the development of epistemic and representational practices (e.g., modeling). Models are inscriptions and fictive representations of real things (e.g., planes, cars, or buildings) or systems (e.g., atomic structure, weather patterns, traffic flow, ecosystems, or social systems) that are simpler than the real objects and systems they represent, but preferentially highlight certain properties of the referent (Rapp & Sengupta, 2012). Modeling is generally recognized as the core disciplinary practice in science, and involves the iterative generation and refinement of inscriptions, which in turn serve as, or provide mechanistic explanations of a referent phenomenon (Giere, 1988; Nercessian, 2002; Lehrer & Schauble, 2002).

Science and math education researchers have shown that engaging in modeling and progressively refining one's representation of some aspect of the world (e.g., a model or an inscription) can contribute to a deeper understanding of mathematical and scientific knowledge and practices (Gravemeijer, Cobb, Bowers, & Whitenack, 2000; Hall & Stevens, 1995). Enyedy (2005) refers to this process as "progressive symbolization". Lehrer (2009) makes clear that, while students need to see and handle models of abstract concepts in order for meaningful conceptual change to happen, the nature of the model is key. Developing a good model involves designing representations that capture essential dynamic features of the relationships they describe, but these representations also edit the relationships, by foregrounding some elements and obscuring or omitting others (Lehrer & Schauble, 2010; Lynch, 1990). Pedagogically, this involves creating opportunities for model evaluation by way of model comparison, i.e., designing curricula that involve the iterative creation of and comparison between different types of inscriptions or models of the same phenomenon (Lehrer & Schauble, 2010; Lesh & Doerr, 2003). This is because models are fundamentally analogies that can only be evaluated in light of comparison with competing models (Lehrer & Schauble, 2010).