Connecting Physics Students' Conceptual Understanding to Symbolic Forms s Using a Conceptual Blending Framework

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In an effort to understand physics students' construction of equations in terms of mathematical structures, previous work has employed a symbolic forms framework. To account for students' contextual physics understanding related to these structures for vector differentials, we mapped symbolic forms into the framework of conceptual blending to model students' construction of equations. This allows us to shed further light on recent literature in this area.

Key words: Physics, Equation, Symbolic Forms, Conceptual Blending

Much of physics involves the construction and understanding of equations. Writing an equation to describe a physical system is a process that entails encoding conceptual meaning of the related physics using specific variables and mathematics symbolism to describe the ways in which the physical variables relate to one another. In many theoretical models used to frame how students use mathematics in physics this process is labeled "modeling" or "mathematization" (Redish & Kuo, 2015; Uhden et al., 2012; Wilcox et al., 2013).

Interpreting the equation as a construct of physical-mathematical language, we present a model for the construction of equations, developed from research on student understanding of non-Cartesian vector differentials (Schermerhorn & Thompson, 2017), that combines a symbolic forms framework addressing the structures through which students understand physics equations (Sherin, 2001) and formal conceptual blending theory from linguistics (Fauconnier & Turner, 2002). In this model the conceptual schema of symbolic forms, which describes the justification for the mathematical structures of an equation, serves as the underlying generic space in a conceptual blending framing of students' construction of equations and thus drives the blend of two input spaces: Sherin's symbol template (the externalized structure of the expression) and content understanding. Symbolic forms were designed as acontextual constructs, independent of content understanding. Therefore, by incorporating conceptual blending theory we can explicitly connect students' content understanding to the expression of terms in an equation.

The proposed model for equation construction allows us to reinterpret recent symbolic forms literature (Jones, 2013; Kuo et al., 2013; Meredith & Marrongelle, 2008) which has interpreted the conceptual schema to be on par with, rather than independent from, content understanding. Conceptual blending literature addressing the interwoven nature of mathematics in physics at both the introductory (Bing & Redish, 2007; Brahmia et al., 2016) and upper levels (Bollen et al., 2016; Hu & Rebello, 2013), has not included the generic space, which serves as an underlying structure for each of the conceptual input spaces and determines which pieces combine to form a new blended concept. Our approach uses features of one framework to fill in the missing analytical aspects of the other framework in these contexts.

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