

Berta's Tower: Understanding Physics Through Virtual Engineering

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Introduction

Learning environments based on engineering design challenges can provide effective contexts for the development of scientific understanding in middle and high school students (Kolodner, Crismond, Gray, Holbrook, & Puntambekar, 1998). In many such environments, however, students solve engineering design problems with physical materials, which can limit the number of iterations of the design cycle in which students can engage. Computational microworlds (diSessa, 2000; Papert, 1980) allow students to develop mathematical and scientific knowledge by programming the behavior of objects in a virtual world. The relative ease of revision in these virtual worlds lets students (a) engage in *bricolage*, a design process marked by repeated iteration and testing of a design rather than explicit planning, and (b) work expressively, incorporating personal choices into their designs (Papert, 1980). *Direct manipulation environments* (Stevenson, 2002) are microworlds without programming, and this poster examines the role of iterativity and expressivity when students developed their conceptual understanding of center of mass engage through solving virtual engineering design challenges in a DME.

Methods

The Berta's Tower project consisted of 2 weekend workshops with a total of 12 middle school students participating. During these workshops, students solved virtual engineering design challenges in SodaConstructor (www.sodaplay.com), a dynamic Java-based spring and mass modeling DME. The tool allowed students to build two-dimensional structures in a drag and drop interface and subsequently test the stability of their designs under the simulated effects of gravity. Clinical pre- and post-interviews of students' (a) understanding of center of mass and (b) experiences in the workshops (post interview only) were transcribed and coded within a grounded theory framework (Strauss & Corbin, 1998).

Results

Students learned about center of mass: Correct references to center of mass increased from pre- to post-interviews (mean pre=0.42; mean post=11.92; $p<0.01$). Students gave more correct justifications for answers to conceptual textbook physics problems in post interviews (mean pre=0.92; mean post=5.92, $p<0.01$).

Properties of the tool helped students learn: When asked about features of SodaConstructor that were important in their design work, 75% of the students (9/12) indicated the ability to test their structures against gravity helped them learn the most; 67% of the students (8/12) identified the ability to incorporate personal design choices into their work (or *expressivity*) as a favorite property of the tool; and 58% of the students (7/12) identified the *combination* of testing and expressivity as the "most fun part" of SodaConstructor.

Discussion

These data suggest the students of the Berta's Tower workshops were able to develop their conceptual understanding of center of mass by solving design challenges in the SodaConstructor DME. The ability to create and revise structures by directly placing spring and mass elements into the design space made it possible for students to learn through *bricolage*, a process that students were motivated to undertake in part because of their ability to incorporate personal choices into their work. The combination of the high iterativity and high expressivity in this DME thus provided an effective context for these students to develop their conceptual understanding of physics.

References

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