Chapter 9

Revisiting the Effects and Affordances of Virtual Manipulatives for Mathematics Learning

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ABSTRACT

In this paper, we revisit the research on virtual manipulatives by synthesizing the findings from 104 research reports, with 46 studies yielding 104 effect size scores reporting the effects of VMs on student achievement. The 104 reports also contributed to a conceptual synthesis analysis that produced categories of affordances that promote mathematical learning. The results of the effect size scores analysis yielded overall moderate effects for VMs compared with other instructional treatments, which was consistent with the first meta-analysis we conducted. There were large, moderate, and small effects when VMs were compared with physical manipulatives, textbooks, and examined by mathematical domains, grade levels, study duration, study quality, year of study publication, and study size. Revisiting the affordance categories confirmed our first analysis which produced five categories of features in the VMs that promoted students’ mathematical learning (motivation, simultaneous linking, efficient precision, focused constraint, and creative variation).

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INTRODUCTION

Four years ago, we completed a review of the literature that led to the first meta-analysis on the effects and affordances of virtual manipulatives for mathematics learning (Moyer-Packenham & Westenskow, 2013). Using 32 research reports and 82 effect size scores from studies conducted up to 2011, our previous findings revealed an overall moderate effect (0.34) on student achievement when virtual manipulatives were compared with other instructional treatments. In our previous paper, we examined the effects of virtual manipulatives on a number of different indicators, including mathematical domains, grade levels, and study duration. The purpose of this paper is to revisit our previous indicators and add a review of some additional indicators (e.g., study quality, year of study publication, and study size).

While the first meta-analysis (Moyer-Packenham & Westenskow, 2013) showed promising results for virtual manipulatives, not all individual studies have confirmed these moderate effects. For example, one of the largest studies (over 300 students) conducted in the past few years comparing virtual manipulatives with physical manipulatives and text-based materials in third- and fourth-grade classrooms demonstrated no significant differences in achievement between the treatments (Moyer-Packenham, Baker, Westenskow, Anderson, Shumway, Rodzon, & Jordan, 2013). This study was particularly important because researchers observed 70% of the lessons and documented teachers’ use of representations, mathematical content, terminology, procedures, manipulative types, passive vs. active use of manipulatives, and other classroom factors. The study showed that, when multiple factors were held constant, there were no differences in student achievement between classrooms using virtual manipulatives and those using physical manipulatives and text-based materials.

THEORETICAL PERSPECTIVE

We use the definition of a virtual manipulative by Moyer, Bolyard, and Spikell (2002): “an interactive, Web-based visual representation of a dynamic object that presents opportunities for constructing mathematical knowledge” (p. 373). This definition applies to both virtual manipulatives driven by a computer mouse and those manipulated on touch-screen devices. A variety of websites feature large collections of virtual manipulatives, including the National Library of Virtual Manipulatives (NLVM) (http://nlvm.usu.edu), National Council of Teachers of Mathematics (NCTM) Illuminations (http://illuminations.nctm.org), and Shodor Curriculum Materials (http://shodor.com/curriculum/). The libraries contain interactive applets (or apps) designed to focus on a single mathematical concept. Many of the virtual manipulatives in the libraries are based on common physical manipulatives (e.g.,
From the Games Industry: Ten Lessons for Game-Based Learning
www.igi-global.com/article/games-industry-ten-lessons-game/53864?camid=4v1a

Artifacts of Expansive Learning in Designing a Web-Based Performance Assessment System: Institutional Effects of the Emergent Evaluative State of Educational Leadership Preparation in the United States
Hanne Mawhinney (2010). *Teaching Cases Collection* (pp. 210-251).
www.igi-global.com/chapter/artifacts-expansive-learning-designing-web/42539?camid=4v1a