

Chapter 104

To Play or to Learn?

A Review of Game-Based Math Learning for Motivation and Cognition

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ABSTRACT

Research evidence of the last two decades indicates positive effects of game-based learning on students' attitude and performance in math education. Game-based Internet math sites are geared to help students stay motivated and master grade-appropriate math concepts. This review presents One) a literature review on game-based learning via instructional design and game design considerations, Two) a tabulated review of 30 Internet math games from a math educator's first-hand experience in playing and critiquing in reference to Grades 6th - 8th players' motivation and cognition. Its educational implications include helping educators (a) select Internet math games with a heightened awareness of Internet games' motivational factors and concept-building potential during gameplay and (b) incorporate game-based technology to foster meaningful immersion when students explore mathematical concepts.

1. INTRODUCTION

1.1. Educational Games

How does playing games help students learn academic subjects? More specifically, in what ways does playing games online help improve students' attitudes toward math learning? It is no secret that American children don't perform as well on math achievement tests as their counterparts from other cultures. Program for International Student Assessment (PISA) (International Data Explorer,

2013) offers a snapshot that adolescent students in the U.S. fall behind in comparison with those from other countries. Over the past decades American educators have revamped the k-12 math curriculum to shift the focus in the learning objectives (Baker, Knipe, Collins, Leon, Cummings, Blair, Garnson, 2010). Researchers have gained significant understanding of blending the entertaining aspect of gaming into the learning activities (Betz, 1995, Gee, 2007, Malone, 1981, Dempsey et al, 2002). Such "edutainment" (Lepper & Chabay, 1985) provides a much higher motivational value

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for the learners. Game designers such as Prensky (2001) acknowledged that digital learning games were the highly exciting medium that combined serious learning into interactive entertainment.

Children born in and after the 1990s are raised in an environment with mobile electronic devices and all-time connection to the Internet. With young children spending up to 10,000 hours of computer or video games by the time they turn 21 (Prensky, 2003), game-based learning will remain an important topic in education in today's digital era because our digital natives (Prensky, 2001b, 2003) are growing up having adapted to multitasking in the world of hypermedia. Learning mathematical concepts through gaming is no exception.

1.2. Playing for Fun vs. Learning for Mastery

The term "Educational Games" suggested its oxymoronic nature in the traditional pedagogy. The conventional purpose of using classroom games was to supplement instruction, and help students drill and reach mastery. These learning-oriented gaming activities were often deemed as "boring" in students' eyes (Prensky, 2003). On the other hand, game without an obvious academic objective meant fun, something people pursued for entertainment, for leisure. Young children do learn through play, however, fun is replaced by work once they enter formal education (Lepper & Chabay, 1985). Although Csikszentmihalyi and LeFevre (1989) find that people gain positive experience in both leisure and obligatory situations when fully immersed in the activity, young learners tend to view a learning [math] game as work (Ke, 2008, Van Eck, 2006a).

As the modern day technology develops, educators and instructional researchers insert learning materials with better engagement tools into a compact play module in the form of a classroom game, video game, computer game, and to the latest, massive-multiple-player game that relies on the high speed of hypermedia technology. As long as

there are clearly defined goals, rules, and payoffs, a set of activities with one or more players can be called a "game" (Dempsey, Haynes, Lucassen, & Casey, 2002). From the gaming perspective, Prensky (2003) shares his astute observation: "kids like all humans love to learn when it isn't forced upon them. Modern computer and video games provide learning opportunities" frequently and quickly. Today's math educational games are no exception: gone are the blatantly obvious learning objectives and instead, there is the increased playability and readily accessibility on websites and as apps. Students, parents, and educators can find math games for virtually any topic for grades K through lower high school grades.

A significant amount of research evidence validates that Internet educational games effectively serve their purposes in engaging students, and possibly inducing meaningful learning. Apart from the ongoing research regarding game-based cognitive gain in math learning, researchers and educators on the forefront of e-learning or game-based learning have produced mixed results (Dempsey, 1996, Van Eck, 2006b) and continue to modify the instructional design in order to address the changing needs of the learners of a modern day classroom. Unlike the digital immigrants (Prensky, 2001b) who learned math with limited interactive tools, today's students spend up to 7.5 hours a day interacting with multimedia (NCTM, 2000). For math educators looking for ways to deepen learners' understanding, we should seek the appropriate blend between the motivational value and the cognitive stimulation in an online math game.

To effectively review both motivational and cognitive effects of game-based math learning, the present review consists of two sections, motivational effects and cognitive effects. Each section includes two subsections, literature review and tabulated game review. The objective of the review is to summarize the key principles in the recent literature on learners' motivation and cognition and use the theoretically and empirically

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