Chapter 52

If the Gear Fits, Spin It Again!
Embodied Education, Design Components, and In-Play Assessments

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ABSTRACT

To understand how students learn while engaged in active and embodied science games, two gears games were created. Would students' gear switching skills during the game be correlated with pre- and post-knowledge tests? Twenty-three seventh graders, playing as dyads, used gestures to manipulate virtual gears in the games. The Microsoft Kinect sensor tracked arm-spinning movements. Paper and pencil gear knowledge tests were administered before and after. In Game 1 (the easier one), the in-game switching data was significantly negatively correlated with only pretest gear knowledge. In Game 2 (the harder one), switching was negatively associated with both pre- and posttests. Negative correlations mean that fewer switches were used and that demonstrated better knowledge of mechanical advantage. In-game process data can provide a window onto learner's knowledge. However, the games need to have appropriate sensitivity and map to the learner's ZPD. In ludo (or in-process) data from videogames with high sensitivity may attenuate the need for repetitive traditional knowledge tests.

INTRODUCTION

The use of immersive games as learning tools has become more accepted in classrooms, and their value has been verified (Merchant, Goetz, Cifuentes, Keeney-Kennicutt, & Davis, 2014). This chapter is an update to the 2015 article called, *If the Gear Fits, Spin It*. This chapter version includes a simpler

interpretation in the discussion section, more insights on game design, and some updated references to augmented and virtual realities (AR/VR).

While much research supports the assertion that serious games can be more effective in terms of learning (d = 0.29, p < .01) and retention (d =0.36, p < .01), than conventional instruction methods (Wouters, Nimwegen, Oostendorp, & van der Spek, 2013), others have found more limited results in academic domains (Young et al., 2012). The Embodied Games lab has published primarily on mixed reality games and simulations, we have consistently observed that when a comparative class is instructed using game components versus more traditional pedagogies, then the game-based class more often produces better learning outcomes (Johnson-Glenberg, Birchfield, Koziupa, & Tolentino, 2014; Johnson-Glenberg & Megowan-Romanowicz, 2017). The field of STEM and learning games includes domain such as: computer science (Papastergiou, 2009), engineering (Coller & Shernoff, 2009)(Coller & Scott, 2009) and the biological sciences (Lui et al., 2014), to name a few. Coller and Scott (2009) report that the students who were randomly assigned to the videogame-based course showed deeper learning compared to the traditional class students (both groups spent the same amount of time on their course work). A metaanalysis from Young et al. (2012) found evidence for positive effects of videogames on language learning, history, and for exergaming, though they also report *little support for the academic value of videogames in science and math* (Young et al., 2012).

In this reprint of the original article, it is worthy to introduce and explore the concept that not all serious games are created equally. The first author can state unequivocally that she has designed and created games that fall along a spectrum of lame to excellent. Part of the noise in discerning the worth of videogames on STEM learning, and the difficulty in interpreting meta-analyses on games and learning, is that well designed games are lumped together with poorly designed games. In addition, the field still debates the difference between simulations and games. E.g., we opted to call our game-like activities *simulations* in Johnson-Glenberg and Megowan-Romanowicz (2017). Mishra, Anguera, and Gazzaley (2016) succinctly state the obvious.

Scientists are not typically the most proficient video game developers. "Games" developed to accomplish cognitive training goals are frequently limited to the layering on of simple graphic skins and low-level reward to standard cognitive task paradigms. This gamification approach often involves sprinkling game elements on top of low-engaging cognitive tasks, creating slightly less boring exercises, which may be a factor driving the negative findings that have dominated the field. (p. 214.)

It takes a team to create good games, and educators and scientists are not professional game designers. Those of us who trained as learning scientists or educators and wish to create serious games need to pair with professional game designers. In the early days of reviews, it was difficult to find professional grade learning games, but there may be a critical mass now. If the newer meta-analyses were to only include game content that has been designed by small teams of experts, then the field may begin to see more consistent, and positive results on the effects of games for learning. In addition, the field needs more articles that mesh rigorous randomized control trial (RCT) data and quasi-experimental data with clear advice on design for learning. To that end, this article will expand on how gameplay components correlate with traditional knowledge tests, and will end with a set of design guidelines. It is also necessary to understand how some long-held traditions in the entertainment game domain may not translate well into the education game domain. Some of the more established award mechanisms used in entertainment games, e.g., leaderboards and badges, may not be appropriate for classroom environments. A 6-week

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