Exploring the Efficacy of a Game-Based Learning Application in Undergraduate Mathematics: Functions of the Machine

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Covariational reasoning is at the heart of many pre-calculus concepts and is vital for calculus readiness (Cottrill et al., 1996; cited in Carlson, Jacobs, Coe, Larsen & Hsu, 2002). To explore the efficacy of a game-based learning application to facilitate conceptual understanding of function concepts through covariational reasoning, the University of Oklahoma's Virtual Learning Experience Team developed a digital game titled "Functions of the Machine". In the game, the student plays the role of a scientist tasked with making a complex machine run. The student explores, tests and fixes the machine's moving parts that consist of gears, fluid tanks, and conveyor belt contraptions. Through a series of interactive scaffolded problems, students transition from proportional reasoning to complex covariational reasoning simulations.

Keywords: Covariational Reasoning, Game-Based Learning, College Algebra

According to Carlson, Oehrtman, and Engelk (2010) it has been well established that pre-calculus level students' thought processes for function concepts are primarily procedural and indicative of an action view of functions (Carlson, 1998; cited Carlson et al., 2010). Furthermore, covariational reasoning, described as the ability to interpret the relationship between two varying quantities as they continuously change, has been documented to be a challenge for even "academically talented" undergraduate students (Carlson, 1998; cited in Carlson, Jacobs, Coe, Larsen & Hsu, 2002, p. 353). A meta-analysis conducted by Vogel et al. (2006), reported with high validity that interactive educational computer games were associated with more significant cognitive gains and more desirable learning attitudes compared to traditional teaching methods (Vogel et. al., 2006). The University of Oklahoma Virtual Learning Experience Team developed a digital game titled "Functions of the Machine" to address the following research question: Is a visually dynamic game-based learning environment associated with better cognitive outcomes in covariational reasoning compared to visually static traditional homework or non-game-based covariational homework? It is hypothesized that the visually dynamic game-based learning environment may be better equipped at helping students develop covariational reasoning. A randomized controlled design was used to test this hypothesis. Students enrolled in College Algebra and Pre-Calculus for Business, Life, and Social Sciences at the undergraduate level were recruited and randomly assigned to one of three conditions: digital game play, traditional problems, or covariational problems without a game environment. All three conditions completed demographic and engagement surveys, pre-post assessments, and a subset of items from The Attitudes Toward Mathematics Instrument (Tapia & Marsh, 2004). Data collection and analysis is still ongoing; results will be presented at a later time.

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