

Chapter 53

Integrating Music Into Math in a Virtual Reality Game: Learning Fractions

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ABSTRACT

The purpose of this study was to investigate future teachers' experiences and perceptions of using a virtual reality game for elementary math education. The virtual reality game was designed and developed to integrate a musical activity (beat-making) into the math learning of fractions. Five math education major students participated in this study. Participants' perceptions, experiences, and interactions regarding the game were examined through observation, screen recording, survey, and interviews. A thematic analysis found three major themes: Transformative presentation of fractions via musical concepts, integration of music into math to enhance learner motivation, and learning-constructive game design features. The findings showed that the concept of fractions is effectively represented via beat-making in the virtual reality game. The study also illustrated that musical term clarification and adaptive, haptic manipulation are salient design features that influence game-based learning.

INTRODUCTION

Music lends itself well to mathematical treatment, in large part, because of all the structure inherent in music. - Leon Harkleroad

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Since video games appeared 40 years ago for the purpose of entertainment, they continue to expand in their application and delivery modes. In their review of literature, Connolly, Boyle, MacArthur, Hainey, and Boyle (2012) noted that learning and serious games have an equal market share as entertainment games. Games are regarded as a good vehicle for learning that is active, situated, and problem-based (Connolly et al., 2012). Learning outcomes of video games vary, including knowledge acquisition (De Lucia, Francese, Passero, & Tortora, 2009; Papastergiou, 2009), motivational change (Kim & Ross, 2006; Papastergiou, 2009), and social aspects such as influence of culture, self-disclosure, and communication media (Assmann & Gallenkamp, 2009).

The design of an effective video game for the purpose of learning relies on that of key game features, such as core mechanics (i.e., game actions and rules), information representation, the reward system, and game-learner interactions (Plass et al., 2013). The way in which information is represented has critical implication on the design of content-specific learning games. According to the principle of information representation, iconic (pictorial) form enhances the conceptual understanding more than symbolic (textual) form in the subject matter that composes high cognitive loads for learners with low prior knowledge, such as mathematics (Lee, Plass, & Homer, 2006; Plass et al., 2013). In a recent effort to use an iconic form in math learning, Devlin (2013) described the potential of connecting math and music learning. Video games can provide learners with a tangible interface to comprehend and interact with mathematical concepts when studying piano and musical concepts. Music accommodates math by representing its symbolic forms (e.g. addition, subtraction, multiplication, and division) by means of musical, iconic forms (e.g. counting beats and dividing into measures), and the immersive game environment will facilitate this process. In light of this inherent connection between music and math, the present study explores the way a video game can be used to teach math through musical concepts.

BACKGROUND

Inherently Integrated: Math and Music

For over two and a half thousand years, there has been much discussion on how music is associated with math in human cognition (Southgate & Roscigno, 2009). One of the earliest discussions we are able to identify is in the Ancient Greek age in which Pythagoras regarded the world as a gathering of ratios and proportions (Ferreira, 2002). Pythagoras reported a high correlation between musical and mathematical concepts, such as between consonant sounds and simple number ratios, and asserted that music and math share a common fundamental basis (Bibby, 2006).

Following Pythagoras's early proposition regarding the relationship between math and music, there has been continuous interdisciplinary research on the integration and relation between math and music. A variety of studies examining musical content through mathematical metaphors and concepts have been conducted. For example, Neuwirth (2002) described that *Das wohl temperirte Clavier*, composed by Johann Sebastian Bach, is comprised of common factors across the disciplines of music, mathematics, and science. Johann Sebastian Bach provided musicians and performers with explicit mathematical codes in the appendix of his music sheets of *Das wohl temperirte Clavier*, and suggested that they play scales and chords with the frequencies signified by the given math codes. Based on Bach's example, Neuwirth (2002) claimed that listeners can describe musical facts in mathematical language.

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