Chapter 11
Play in the Museum:
Design and Development of a Game-Based Learning Exhibit for Informal Science Education

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ABSTRACT

Digital games have been found to yield effective and engaging learning experiences across a broad range of subjects. Much of this research has been conducted in laboratory and K-12 classrooms. Recent advances in game technologies are expanding the range of educational contexts where game-based learning environments can be deployed, including informal settings such as museums and science centers. In this article, the authors describe the design, development, and formative evaluation of Future Worlds, a prototype game-based exhibit for collaborative explorations of sustainability in science museums. They report findings from a museum pilot study that investigated the influence of visitors' individual differences on learning and engagement. Results indicate that visitors showed significant gains in sustainability knowledge as well as high levels of engagement in a free-choice learning environment with Future Worlds. These findings point toward the importance of designing game-based learning exhibits that address the distinctive design challenges presented by museum settings.

INTRODUCTION

Over the past decade, growing evidence has emerged that games are effective learning tools for a broad range of subjects and student populations (Connolly, Boyle, MacArthur, Hainey, & Boyle, 2012; Clark, Tanner-Smith, & Killingsworth, 2016; Wouters, van Nimwegen, van Oostendorp, van der Spek, 2013). Much of the work has focused on two categories of game-based learning: 1) games for formal educa-

tion settings such as schools (Habgood & Ainsworth, 2011; Wouters et al., 2013), and 2) serious games, which typically investigate game technologies for training (Johnson, 2010) or increasing awareness of social, geopolitical, or economic issues (Mitgutsch & Alvarado, 2012). While important, these research directions do not address a notable class of educational contexts that stands to benefit as much, or perhaps even more, from the introduction of well-designed educational games: informal education settings, such as science museums.

Formal education settings, and particularly schools, differ from science museums in several important respects (National Research Council, 2009). Schools and museums serve different populations: Schools are responsible for educating school-age children, whereas museums are visited by learners of all ages. Museums have a particular emphasis on affective outcomes, such as sparking interest and excitement, and they rarely use tests or grades. In schools, learners typically sit at designated desks for prescribed class periods. Museums are free-choice learning environments; visitors come and go as they please, and there is no teacher to provide instruction. Museum learning, quite literally, *looks different* from classroom learning. These distinctions have significant implications for the design of educational games—including pedagogical and gameplay designs—and they merit careful consideration to ensure effective and engaging learning experiences.

In this article, we explore the design of game-based learning environments for museums by presenting a case study of Future Worlds, a game-based learning environment for collaborative explorations of environmental sustainability. Future Worlds is an interactive exhibit designed to enrich museum visitors' understanding of sustainability, promote collaboration and scientific reasoning, and foster engagement in environmental science. We outline the design principles that drove the iterative development of Future Worlds, and we illustrate the methods utilized to investigate Future Worlds' effectiveness for fostering learning and engagement.

BACKGROUND AND RELATED WORK

The affordances of digital games align naturally with the goals of museum education, such as fostering engagement in science, and enabling learners to manipulate, test, and explore hypotheses about the natural world (National Research Council, 2009). However, designing game-based learning environments presents several challenges. Game design is multidisciplinary, requiring close collaboration between software developers, educators, artists, testers, and other specialists. Games are complex, requiring myriad design decisions with uncertain impacts on learners' experiences. Most notably, there is a dearth of evidence-based research on the design principles and methods necessary for creating effective game-based learning environments.

Reviews of the game-based learning literature have broadly concluded that games can yield positive learning outcomes across a range of educational subjects (Connolly et al., 2012). In recent years, a pair of prominent meta-analyses independently concluded that, in general, digital game technologies are often more effective than traditional instructional methods in fostering learning and retention (Clark et al., 2016; Wouters et al., 2013). Expanding on this conclusion, Wouters et al. (2013) advise, "the next step is more value-added research on specific game features that determine ... effectiveness" (p. 262). Clark et al. (2016) echo this argument, concluding, "[Research on game-based learning] should thus shift emphasis … to cognitive-consequences and value-added studies exploring how theoretically driven design decisions influence situated learning outcomes" (p. 116).

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