Chapter 2.6

Effective Knowledge Development in Game–Based Learning Environments:
Considering Research in Cognitive Processes and Simulation Design

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ABSTRACT

Serious games are, at their core, exploratory learning environments designed around the pedagogy and constraints associated with specific knowledge domains. This focus on instructional content is what separates games designed for entertainment from games designed to educate. As instructional designers and educators, the authors want serious game play to provide learners with a deep understanding of the domain, allowing them to use their knowledge in practice to think through multifaceted problems quickly and efficiently. Attention to the design of serious game affordances is essential to facilitating the development of domain knowledge during game play. As such, the authors contend that serious game designers should take advantage of existing prescriptions found in research on knowledge development in exploratory learning environments and tests of adaptive instructional designs in these environments. It is with this intention that the authors use evidence from research in cognitive processes and simulation design to propose design heuristics for serious game affordances to optimize knowledge development in games.

INTRODUCTION

Zyda (2005) defines serious games as "a mental contest, played with a computer in accordance with specific rules, that uses entertainment to further government or corporate training, education, health, public policy and strategic communication objectives" (p. 26). Serious games present players with a contextualized problem, rules (guided by constraints associated with the content), multiple interacting elements, and cognitive tools that allow users to freely discover solution paths in the tradition of exploratory, problem-based learning. In a way, serious games can be thought of as a sense-making activity; players are constrained by the rules associated with their domains (situated context) but otherwise use the affordances in the game to make sense of domain-related concepts needed to complete game objectives. For example, to represent the fact that mixing acids and bases will cause an explosion, it is necessary to generate a rule to restrict actions in a chemistry game.

Unlike training simulations, which are held to realistic representations and high levels of detail at all levels, serious games are able to place players in fantastic situations where they are asked to take on specific roles and where representations might be simplified to focus on target knowledge (Crawford, 1984). While in the game world, players observe the consequences of their decisions and are constantly challenged to fill knowledge gaps through problem solutions that require retrieval of prior knowledge (Van Eck, 2007). As they work to fill these knowledge gaps, players integrate domain knowledge into their cognitive systems, thus gaining knowledge of the domain (Foster & Mishra, 2009).

Serious game environments are inherently complex, as there are many elements working in harmony to create the game experience. Potential for collaboration, cross disciplinary activities and situated learning are all possible in a well-designed serious game. Gee (2004) suggests designers focus on designing games to keep learners hooked (even when dealing with complex information). He suggests approaches like well-defined problem statements and practice in context to sustain the players' interest throughout the life of the game. Certain properties such as motivation (Low, this volume), flow (Reese, this volume), and adaptability (Magerko, Heeter & Medler, this volume) are also essential to creating an environment where learners want to play and are motivated to come back and replay.

Designers of serious games can take advantage of the freedom to simplify representations, insert features such as custom avatars, transition scenes, inventories, maps, and non-player characters and focus on necessary domain knowledge by carefully crafting problems, rules and cognitive tools: what we refer to as serious game affordances. To design a serious game that is not only entertaining but also educational, these affordances should be designed with careful attention to the cognitive development of the players; we feel these considerations are critical to the serious game design process. The purpose of this chapter is to provide heuristics for the design of serious game affordances to support the learner as they develop their domain understanding.

To construct these heuristics, we will examine research in cognitive processes related to knowledge development from within the framework of the development of expertise. We begin with a review of the literature on development of expertise to provide evidence of the most efficient means of supporting a learner as they move from domain novice to expert thinker and beyond. We use these findings to address a critical issue in serious game design: the development of a player-driven exploratory learning environment that supports the development of domain-related schema through verified supports and affordances. To facilitate optimal serious game design, we propose a set of design heuristics specifically aimed at supporting knowledge development for meaningful learning outcomes.

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