Chapter 11
Designing Intrinsic Integration of Learning and Gaming Actions in a 3D Architecture Game

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ABSTRACT
This chapter reports a design-based study that examines core game mechanics that enable an intrinsic integration of domain-specific learning. In particular, the study aims to extract the design heuristics that promote content engagement in the actions of architectural construction in Earthquake Rebuild, a 3D epistemic simulation game that aims to promote active math learning for middle-school students. Data were collected from iterative expert reviews and user-testing studies. Based on the study findings, the chapter presents qualitative, analytic speculations on the design of the game-play mode and perspective, the granularity level, the user input interface, and incentives for attentive content engagement that will reinforce the learning affordance and playability of the core game gaming actions.

INTRODUCTION
A common motivation for using a creative and playful learning environment, such as digital game-based learning, is to provide an engaging and contextualized setting for active and experiential learning – learning that usually focuses on the processes of problem solving, inquiry, and critical thinking (Garris, Ahlers, & Driskell, 2002; Gee, 2009; Kiili, 2007). Yet the design mechanism on how to integrate and map content engagement and domain-specific thinking into gameplay to create meaningful game-based learning is still ambiguous, in spite of the plethora of research on digital game-based learning.

The construct of gameplay contains two layers: the “ludus” or game mechanics layer that involves rules and actions, and the narrative layer that comprises the setting, plot, and/or characters (Ang, 2006; Frasca, 1999). Although research is still inconclusive as to whether game design is more the design of experience (Salen & Zimmerman, 2004) or a narrative architecture (Jenkins, 2002), not all games tell a story. The narrative layer is not a defining feature for the games of which the narrative representation is

simplest and even tokenized. Hence in the literature, the discussion of *endogenous or intrinsic fantasy* for learning-play integration in games – one in which there is an integral and continuing relationship between game fantasy and the content to be learned – emphasizes an intrinsic integration of content learning in game mechanics beyond the background game world/narrative (e.g., Habgood & Ainsworth, 2011; Kafai, 1995; Ke, 2008; Klopf, Osterweil, & Salen, 2009; Plass et al., 2012; Malone & Lepper, 1987; Squire, 2003). Particularly, it is argued that the extent to which content engagement is intrinsic to the core gaming actions will influence the game’s learning effectiveness (Richards, Stebbins, & Moellerling, 2013). Nevertheless, empirical and theoretical research describing and specifying the design of the intrinsic integration between learning and is still limited and sporadic (Habgood, Ainsworth, & Benford, 2005; Habgood & Ainsworth, 2011).

This chapter reports a design-based study that examines how domain-specific thinking can be intrinsically integrated into gameplay to foster content learning while sustaining the game’s playability. In particular, the study examined the design of math integration in the actions of architectural construction in Earthquake Rebuild, a 3D architecture game that aims to promote active math learning for middle-school students. Data were collected from iterative expert review and user-testing studies. Based on the study findings, the chapter presents qualitative, analytic speculations (Firestone, 1993) on how the design of the play mode, the granularity level, the player perspective, and the player-input interface relates to the learning affordance and playability of the core game mechanic (i.e., gaming action).

**BACKGROUND**

**Game-Based Learning**

Games in general can be defined as organized play that is structured by a set of rules and an obstacle-tackling goal (Klopfer et al., 2009; Schell, 2014; Suits, 1978). For the past two decades, a variety of digital games have been designed and examined for learning purposes (e.g., Barab et al., 2009; Clark, Tanner-smith, Killingsworth, & Bellamy, 2014; Cooper, 2014; Dede, 2005; Klopf, Osterweil, & Salen, 2009; Shute, Ventura, & Kim, 2013; Andersen et al., 2011; Squire, 2003). A game may act as the microworld for the epistemic practice of skills (Shaffer, 2006), provide multimodal representation of conceptual knowledge (Habgood & Ainsworth, 2011), simulate a complex system to facilitate scientific discovery learning (Barab, Thomas, Dodge, Carteaux, & Tuzun, 2005; Cooper, 2014), or support the constructive, learning by design method (Ke, 2014). Game-based learning hence includes acquisition of novel understanding and skills (Sedig, 2008) and application (i.e., retention and transfer) of the previously-learned knowledge (Clark et al., 2011).

A recent meta-analysis on the effectiveness of digital games for learning indicated that games, compared with non-game instruction conditions, have a moderate to strong effect on cognitive learning outcomes (Clark et al., 2014). Importantly, prior research found a significant moderating effect of game design features on the affordances of games for learning (Clark et al., 2011, 2014; Hays, 2005; Ke, 2008; Ota & DuPaul, 2002; Vogel, et al. 2006; Young et al., 2012).

Among game design features, game mechanic is a core and defining facet. The game mechanic can be understood as “a compound activity composed of a suite of actions” (Salen & Zimmerman, 2004, p. 316). The essential activity that players repeatedly perform and directly apply to achieve the end-game state is usually described as a *core mechanic* (Sicart, 2008). According to Järvinen (2008) and Sicart
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