Chapter 7

Exploratory Digital Games for Advanced Skills: Theory and Application

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ABSTRACT

Based on Cognitive Flexibility Theory, this chapter presents a framework for the conception, design, and development of a knowledge network that can be used in exploratory instructional digital games. The instructional structure consists of a set of nodes, each associated with a specific level of conceptual restructuring and a set of resources, both perceptual and physical, that can help the learner/player achieve resolution. The resulting conflict field is used to determine the game structure. Distributed and embodied cognition research is used to link instructional objectives with available game resources at the task level. As a result a better alignment is obtained between the instructional objectives and the game core mechanics. The application of the framework is then illustrated by using it to outline the design process of a game to learn computer programming.

INTRODUCTION

There is a fundamental difference between games and what we usually identify as formal education. Huizinga (1955) notes the capacity of play to absorb and impart meaning to activities that would otherwise be inconsequential. Some consider play a central factor in human learning (Apter, 1991) whereas others point out that learning is the essential motivation behind play (Crawford, 1982). Meaningful play occurs within the ‘magic circle’ (Salen & Zimmerman, 2004) which is the game’s own space and time where people voluntarily participate (Huizinga, 1955). Within this space it is possible to experience a high level of excitement and take risks within a protective frame (Apter, 1991). Motivation is increased by the presence of fantasy, challenge and curiosity (Malone, 1981).

This chapter takes an ecological stance on games. The digital medium allows the player to actively explore spatial quality and act on the virtual world participatory affordance (Murray, 1997). Furthermore, since the player can perceive possibilities for action in the game space, and is given tools to act...
upon those possibilities to reach a goal, games fit the description of lived environments (Allen, Otto, & Hoffman, 2003). From this perspective, the purpose of instruction is to motivate the learner to set specific goals and detect relevant information and actions in the environment that can lead to these objectives (Young, 2003). Whether those goals emerge from the interaction with the environment (Young, Barab, & Garrett, 2000) or are personal, an important skill will be identifying which of the affordances are most effective to achieve specific goals (Gee, 2008). Learning is then the result of this perceiving-acting cycle (Young, 2003, 2004; Young et al., 2000).

In line with the previous argument, computer games for instruction can benefit from an instructional strategy consistent with the characteristics of the digital medium. Steinkuehler (2006) states that “games typically consist of overlapping well-defined problems enveloped in ill-defined problems that render their solutions meaningful” (p. 2). Designers of games that have this structure, however, have no clear guidelines on how to create the underlying network of well-defined problems that can be explored rather than completed sequentially as it happens in traditional instruction. Cognitive Flexibility Theory (Spiro, Feltovich, Jacobson, & Coulson, 1992; Spiro & Jehng, 1990; Spiro, Vispoel, Schmitz, Samarpungavan, & Boerger, 1987) is presented here as the basis of an approach that can guide the conceptualization of the knowledge structure, one that will better use the affordances of the digital environment while at the same time providing the learner with the opportunity to gain a deeper understanding of the specific domain. The result is a network that can act as the underlying structure of the game, inducing learning through exploration and conflict resolution. The idea of cognitive conflict is further explored in the context of a critical thinking/problem-solving continuum which can inform learner progression as well as the type of tasks involved.

From the point of view of the learning processes involved, current work tends to focus on either internal processes or context but what is desirable is a theory that integrates mental processes with the perceptual, motor, and embodied dimensions of learning, among others (Gee, 2008). Beyond internal cognitive processes, the perceiving-acting cycle suggests that the resources present on the screen play a very important role. For example, Massively Multiplayer Online Games (MMOGs) can be optimal educational playgrounds (Squire, 2006) where large amounts of information are present through a variety of interface elements. However, it is unclear how players interact with the many resources available or how this interaction can be of use in instruction (Schrader & Lawless, 2008). Commercial game designers are starting to approach this issue from a human-computer interaction perspective (Dyck, Pinelle, Brown, & Gutwin, 2003; Jorgensen, 2004). This chapter argues that the Distributed Information Resources Model (DIRM) (Wright, Fields, & Harrison, 2000) provides a reference that can help in this analysis. Although this model is more relevant when learning how to use a computer application, it can help determine what kinds of resources are desirable in an instructional game.

Furthermore, interaction with a digital environment is not limited to cognitive and perceptual skills. The use of the keyboard, mouse, and game controllers require motor skills that can be central to the gameplay. Studies on embodied cognition (Ballard, Hayhoe, Pook, & Rao, 1997; Gray & Fu, 2004; Gray, Sims, Fu, & Schoelles, 2006) can inform the analysis of how individuals choose between cognitive, perceptual, and motor skills, the way in which this decision impacts learning, and therefore the way we design the physical interaction with an instructional game.

Many authors have proposed frameworks and guidelines for the design and development of instructional games (Boocock and Schild, 1968; Abt, 1968; Duke, 1974; Greenblat and Duke,
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