Chapter LXIV
GaME Design for Intuitive Concept Knowledge

Debbie Denise Reese
Center for Educational Technologies®, Wheeling Jesuit University, USA

ABSTRACT

Game-based, metaphor-enhanced (GaME) design is a process for engineering instructional games to prepare learners with the prior knowledge they need to learn later, more complex science concepts. The key step in the method is specifying a domain's relational structure and then developing a game world based upon that structure. Reviewing relevant game design, cognitive science, and learning science theories, the author argues: (a) the need for GaME design; (b) that game worlds, complex concepts, and mental models are analogous systems; (c) how game-based technologies can provide a pragmatic and embodied context for making complex, introductory concepts intuitive; and (d) that the pragmatic, physical, and procedural aspects of games make them powerful learning tools that must be carefully designed. The author illustrates GaME design using Selene: A Lunar Creation GaME. Rigorous methods for design of instructional games will enhance control over learning outcomes.

DESIGNING GAMES FOR INTUITIVE CONCEPT KNOWLEDGE

Meaningful learning requires activation of relevant prior knowledge (Ausubel, 1962, 1963). Learners who encounter a new concept equipped with relevant, activated, adequate prior knowledge will find the new concept intuitive. When concepts are not intuitive, learners often struggle and may fail (Hestenes, Wells, & Swackhamer, 1992). When learners do not have prerequisite knowledge, instruction should provide relevant experience (Merrill, 2002). This chapter summarizes how game-based, metaphor-enhanced (GaME) learning objects can help learners construct viable prior knowledge from game play experience. Learners play a GaME to construct prerequisite knowledge that will prepare them for direct instruction.

The GaME research program is founded on the assumption that game-based technologies are powerful learning tools (Gee, 2003, 2005a).

The program specializes in one type of learning objective and one event of instruction:

- **Learning objective:** Complex, introductory concepts
- **Event of instruction:** Prior knowledge

GaMEs are engineered to make complex concepts both embodied and intuitive. A GaME:

- Is **ga**me-based. A GaME has goals, a system, and game play. The goal is to motivate targeted learning. In addition, transactions within the game world connect learning to the player's sensory and perceptual systems.
- Is **m**etaphor-**e**nhanced. GaME design applies cognitive science theories of analogical reasoning. The GaME world, its relational system, and the game goal are analogs for the targeted conceptual domain. The GaME lets learners construct sound and viable mental models of targeted conceptual domains.
- Is a learning object. A GaME functions as a self-contained, decontextualized instructional module.
- Accelerates the experience. A good novel or movie focuses on experience salient to its story and compresses days, years, and even lifetimes in a few hours. GaMEs focus on experience relevant to the targeted conceptual domain. Over a few hours of engineered game play, players experience days, years, and even lifetime equivalents of viable transactions with the target domain.

A GaME design team specifies the relational structure of the target domain and then defines an analogous GaME world of time, space, and the objects and relations that define them. Within the GaME world these become relevant lived experience for learners. Learners construct a model of how to progress through the GaME system. They form hypotheses and test them, developing a mental model analogous to the targeted domain by creating viable prior knowledge. Research has shown that lived experience in the physical world often leads to mental models that make science concepts counterintuitive (Hestenes et al., 1992). GaMEs are engineered for lived experience within a GaME world that makes science concepts intuitive.

A team of researchers, content experts, programmers, and designers has produced the first GaME prototype, *Selene: A Lunar Creation GaME*. In *Selene* players learn key lunar geology concepts: stratigraphy, accretion, differentiation, impact cratering, and volcanism. *Selene* is a concrete, transactional analog of introductory lunar geology.

EMBODIED KNOWLEDGE CAN MAKE SCIENCE COUNTERINTUITIVE

Students often find abstract, introductory science concepts counterintuitive in domains like chemistry (Gabel, 1999; Gabel & Sherwood, 1983), biology (Baker & Lawson, 2001), and physics (Hestenes et al., 1992). Gabel and her colleagues explained that chemistry concepts challenge students because people function on a macro (sensory or embodied) level, and chemistry requires thinking in a symbolic way about the sub-micro (particulate) level. Hestenes and his colleagues showed that people build intuitions about how the physical world functions based upon their perceptions of the effects of physical forces on their bodies and surroundings. These common-sense mental models are extremely robust and make introductory physics concepts counterintuitive:

Specifically, it has been established that: (1) commonsense beliefs about motion and force are incompatible with Newtonian concepts in most respects, (2) conventional physics instruction