Chapter 21
Dino Lab:
Designing and Developing an Educational Game for Critical Thinking

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ABSTRACT

Dino Lab is a serious game designed to explore the potential of using games in scientific domains to support critical thinking. Through collaborations with educators and scientists at the Natural History Museum of Utah (NHMU), game designers and learning scientists at the University of Utah, and Title I middle school teachers and students, the authors have developed a beta version of Dino Lab that supports critical thinking through engagement in a simulation-based game. Dino Lab is organized around four key game stages that incorporate high-level goals, domain-specific rule algorithms that govern legal plays and resulting outcomes, embedded reflection questions, and built-in motivational features. Initial play testing has shown positive results, with students highly engaged in strategic game play. Overall, results suggest that games that support critical thinking have strong potential as student-centered, authentic activities that facilitate domain-based engagement and strategic analysis.

INTRODUCTION

Dino Lab represents a collaborative effort among educators and scientists at the Natural History Museum of Utah (NHMU), game designers from the Games and Apps Lab (GApp Lab) at the University of Utah, a cognitive learning scientist from the University of Utah, and Title I middle school teachers and students. Dino Lab is an educational, or serious, game that uses digital representations of actual

museum objects (i.e., dinosaur fossils) to facilitate engagement in and practice with a set of key cognitive processes involved in critical thinking. This chapter describes how museum objects and paleontology research, research on critical thinking processes, and principles of game design were synthesized and balanced during the conceptualization, development, and refinement of Dino Lab. Using examples from Dino Lab's iterative development cycles, we discuss our findings about the potential boundaries between educational and entertainment features in games for critical thinking. We also highlight key challenges in creating educational games that target complex cognitive processes. Finally, we share a set of principles for future development of educational games for critical thinking as informed by lessons learned during this project.

BACKGROUND

Game Context

Dino Lab grew out of NHMU's Advancing Critical Thinking (ACT) project, an on-going effort to identify opportunities for improving the critical thinking skills of K-12 students. Over the past two years, NHMU's ACT project has focused on ways in which its museum collections and research, combined with advancements in 3D technologies and serious games, could be leveraged to support middle school teachers and students as they work together to build the critical thinking skills needed in nearly every area of their required curriculum. The program concept that resulted from this work is called *Research Quest*. Research Quest is envisioned as a set of scientific, research-based investigations that follow a standardized format in supporting authentic, student-centered and inquiry-based critical thinking in multiple STEM domains.

Currently, a pilot Research Quest titled *Mysteries of Cleveland Lloyd* has been developed that uses three major, inquiry-based components. These components can be implemented in quick succession or spread out across several weeks when used in a classroom environment. The Dino Lab game is one of the three Research Quest components. Like the other two components, Dino Lab can stand alone or be used in conjunction with the other activities. Dino Lab is a simulation-based game that teaches students to engage in critical thinking via evidence-based inquiry. Direct connections between Dino Lab's features and critical thinking skills are described in a later section of this chapter (see "Dino Lab Support for Critical Thinking"). The purpose of the Dino Lab portion of Research Quest is to understand how, when, and why certain physical features aid in a dinosaur's survivability. By design, the complexity of the Dino Lab game is represented as a rich matrix of feature combinations and survival outcomes where the success or failure of most dinosaur "builds" can only be determined by multiple interactions among selected features in combination. As described later in this chapter, consultation and think-alouds with paleontologists informed the rules and interactions that determine success in Dino Lab.

In addition to Dino Lab, Research Quest: Mysteries of Cleveland Lloyd includes two additional inquiry activities that rely upon technology-supported access to museum objects (e.g., 3D virtual models of scanned museum objects; in this case, dinosaur fossils) and authentic materials used by domain scientists (e.g., the bone map of the quarry where the dinosaur fossils were found). First, students use 3D models of known species to create evidence-based hypotheses about the identity of new "mystery fossils" found in the quarry. Although the mystery fossils are unknown to students, they have been examined and identified previously by NHMU scientists. Students work to identify the mystery fossils and compare

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