Chapter VI

Learning Science Concepts with Haptic Feedback

Linda D. Bussell, Kinder Magic Software, USA

Abstract

This chapter examines the use of haptic feedback in a multimedia simulation as a means of conveying information about physical science concepts. The case study presented herein investigates the effects of force feedback on children’s conceptions of gravity, mass, and related concepts following experimentation with a force-feedback-enabled simulation. Two groups of 17 children conducted experiments with the simulation; the experimental group used both visual and force feedback, and the control group used visual feedback only. Evidence of positive gains by the experimental group who used the simulation with force feedback is presented. Guidelines for applying these technologies effectively for educational purposes are discussed. This chapter adds to the limited research on the application of haptic feedback for conceptual learning and provides a basis for further research into the effects of computer-based haptic feedback on children’s cognition.
Introduction

Force feedback can add realism and enjoyment to our computer gaming experiences, and haptic (tactile and force) feedback is used for applications that have a critical psychomotor aspect, such as flight and surgical training. Haptic feedback has been used to adapt educational software for students with visual impairment, and there is evidence that it can enhance the usability of software for those with normal vision.

This chapter will investigate the use of multimedia simulations with haptic feedback for conceptual learning. Theories of cognition that may illuminate the process of learning through multimedia simulations and haptic interfaces are considered, and a case study of children’s experimentation with a simulation incorporating force feedback is presented. Implications of the research and principles that may serve to guide the effective use of multimedia and haptic feedback are discussed.

Background

The following literature review presents evidence that force feedback within a simulation may hold potential to promote conceptual development in children. Relevant theories of cognition will provide a framework for considering the process of learning through multimedia simulations and haptic interfaces. Next, related research on the use of multimedia, simulation, and haptic technology for educational applications is reviewed.

Physical Interaction, Embodied Knowledge, and Cognition

Touch is essential to normal human development (Blackwell, 2000). As we strive to make sense of our experiences, our understanding of forces plays an essential role (Johnson, 1987; Lakoff, 1987; Piaget, 1930). We learn about our world through this interaction. Our sense of touch helps us to form mental models of the shape and structure of objects; we learn to recognize many objects by touch alone. Through these direct experiences, our bodies become more aware of natural forces than our conscious minds do. We learn to hit a moving target such as a ball by trying repeatedly until we are successful. Our muscles learn how much force to apply and in what direction to place the ball where we want it. This embodied knowledge is implicit, automated expertise gained through years of elaboration and practice under countless conditions, and so imposes little cognitive load (Anderson, 2000).
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