Chapter 8
Simulations for Supporting and Assessing Science Literacy

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ABSTRACT

Simulations have become core supports for learning in the digital age. For example, economists, mathematicians, and scientists employ simulations to model complex phenomena. Learners, too, are increasingly able to take advantage of simulations to understand complex systems. Simulations can display phenomena that are too large or small, fast or slow, or dangerous for direct classroom investigations. The affordances of simulations extend students' opportunities to engage in deep, extended problem solving. National and international studies are providing evidence that technologies are enriching curricula, tailoring learning environments, embedding assessment, and providing tools to connect students, teachers, and experts locally and globally. This chapter describes a portfolio of research and development that has examined and documented the roles that simulations can play in assessing and promoting learning, and has developed and validated sets of simulation-based assessments and instructional supplements designed for formative and summative assessment and customized instruction.

INTRODUCTION

Digital and networking technologies permeate school, work, personal, and civic activities. They are central, transformative tools for addressing goals and challenges in all walks of life. Conceptualizations of 21st century skills and new literacies go beyond traditional views of academic,

disciplinary learning to emphasize the need to take advantage of the affordances of technologies to foster application of domain knowledge and competencies in real-world contexts, goals, and problems. Research in cognitive science about how people learn has long documented the importance of transferable knowledge and skills and how learning situated in one context must be explicitly

scaffolded to promote use in multiple contexts for new problems. Currently, research and development on the affordances of a vast, ever expanding array of digital and networking technologies are providing evidence of the power of technologies for transforming learning environments and the methods for monitoring and evaluating learning progress.

Technologies are revolutionizing the ways that learning can be both promoted and assessed. Interactive technologies such as computer-based learning environments and physical manipulatives enhanced by digital technologies provide teachers with powerful tools to structure and support learning, collaboration, progress monitoring, and formative and summative assessment. These digital tools enable new representations of topics that are difficult to teach and new approaches to individualized learning, that supports a wider range of learners' needs.

Large-scale national and international studies are providing evidence that technologies are truly changing and improving schools by enriching curricula, tailoring learning environments, offering opportunities for embedding assessment within instruction, and providing collaborative tools to connect students, teachers, and experts locally and globally (Quellmalz & Pellegrino, 2009; Quellmalz & Kozma, 2003; Law, Pelgrum, & Plomp, 2008).

In this chapter, we will describe projects in WestEd's Science, Technology, Engineering and Math (STEM) program that are capitalizing on the affordances of digital tools to deepen and extend the kinds of science learning highlighted in the *Framework for K–12 Science Education* and the *Next Generation Science Standards* (National Research Council [NRC], 2012a, 2012b). These projects draw upon a broad range of recent research to develop and evaluate interactive technologies for learning and assessment. This chapter will describe the principles extracted from work in the learning sciences, model-based reasoning,

multimedia research, universal design for learning (UDL) and evidence-centered design (ECD) and employed in the design and development of these technology tools. We will summarize strategies for successful implementation of these new digital learning tools in current educational settings, as well as studies of the interventions' technical quality and impacts on learning. We will discuss how these interactive technologies support the development of learning progressions and multilevel, balanced assessment systems. We conclude the chapter with a discussion of additional lines of research and development.

BACKGROUND

The research and development projects in WestEd's STEM program draw upon theory and findings from cognitive science and multimedia research and emphasize the schematic and strategic knowledge involved in systems thinking and the science practices related to inquiry-based problem-solving for real-world issues. The focus on real-world applications shifts attention from the inert retention of disconnected scientific domain knowledge to understanding the science relevant to environmental and social issues, making informed decisions, and communicating about the issues.

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