Chapter 14
Development of a Middle School Online Science Curriculum:
Lessons Learned From a Design-Based Research Project

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ABSTRACT

Design-based research methodology was used to guide a line of research to develop, implement, revise, and evaluate the ESCOLAR online science curriculum for middle school students, including general education students, English language learners (ELs) primarily of Hispanic origin, and students with high-incidence learning disabilities (LD). The iterative research approach was carried out in three stages with multiple steps per stage: (1) Stage 1, or informed exploration, identified and described the problem under investigation; (2) Stage 2, or enactment, redesigned previously developed online science units, implemented each unit in case studies, and completed a feasibility evaluation; and (3) Stage 3, or evaluation of local impact, documented the efficacy of the science curriculum with a randomized controlled trial. The present chapter focuses on the second and third stages, demonstrating the process by which the ESCOLAR curriculum was repeatedly refined with input from stakeholders, and then examined for feasibility of implementation, usefulness in helping teachers engage with students, and efficacy in deepening student science knowledge. Data were drawn from multiple sources, including teacher logs, student and teacher surveys, web analytics, student notebooks, content assessments, and focus groups. Results indicate that the ESCOLAR curriculum was feasible to implement, useful, and effective, and may now be adopted as an evidence-based intervention to enhance science learning among diverse students. The data-driven, design-based research methodology proved to be a practical framework, and underscored the critical importance of considering all stakeholders in the process of curriculum design, refinement, and evaluation. This chapter offers a model for the development of constructivist science instructional materials for ELs and students with LD using online, multimedia technology.

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INTRODUCTION

Hispanic and other minority students, as well as students with high-incidence learning disabilities (LD), are often underrepresented in the fields of science, technology, engineering, and mathematics (STEM) (National Science Foundation, 2018). To increase STEM representation among these groups, evidence-based instructional programs can be developed—and design-based research methodology offers a useful framework for researchers conducting this work (Dede, 2005; 2004). Unlike educational programs conceived in a laboratory alone—which may not translate well into practice—the iterative, design-based research process encourages participation from stakeholders at all stages of development and testing, with the ultimate goal of building instructional programs that are appropriate, culturally sensitive, effective, and workable in the classroom. Design-based research methodology promotes the development of use-inspired interventions to increase learning and interest under real-world conditions.

This chapter reports on how design-based research methods were employed in the development, implementation, and evaluation of an active use of educational technology—specifically, the ESCOLAR (Etext Supports for Collaborative Online Learning and Academic Reading) middle school online science curriculum, which supports learning among general education students, English language learners (ELs), and students with LD. The present chapter expands on the authors' previously published reports from a case study (Terrazas-Arellanes, Knox, Rivas, & Walden, 2014), a feasibility study (Terrazas-Arellanes, Knox, & Walden, 2015), and a randomized controlled trial (Terrazas-Arellanes, Gallard, Strycker, & Walden, 2018). Here, we present a broader perspective on the design-based research process (Anderson & Shattuck, 2012) used to guide this line of research, including intervention development, revision, and evaluation across multiple studies to accumulate increasingly strong evidence of program appropriateness, feasibility, replicability, consumer satisfaction, effectiveness, and efficacy.

The line of research described here is rooted in prior published studies on technology and science learning among diverse learners. Relevant research on science instruction and technology use for ELs and students with LD is reviewed briefly below.

LITERATURE REVIEW

Academic Achievement of ELs and Students With LD

Nationwide, ELs comprise 9.5% of the K-12 student body, with rates ranging from 1% in West Virginia to 21% in California; rates overall have increased since 2000 (U.S. Department of Education, 2018). In the U.S., most (77.1%) ELs have a home language of Spanish or Castilian, comprising over 3.5 million U.S. students. U.S. Department of Education statistics for 2015-16 indicate that 6.7 million students were eligible for special education in the U.S., about 14% of the K-12 population; across disability categories, learning disabilities were the most prevalent, with 34% of students in special education qualifying (U.S. Department of Education, 2018).

The National Assessment of Educational Progress (NAEP; National Center for Education Statistics [NCES], 2018a; 2018b) shows some recent improvement in science test scores for fourth-, eighth-, and 12th-grade Caucasian, African-American, and Hispanic students. However, achievement gaps remain, particularly with ELs and students with LD (NCES, 2018a; 2018b). Students with LD have poorer science test scores than students without LD. On the NAEP science test, students with LD scored lower

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