# Abstract

Promoting Mechanical Reasoning with the Simple Machines Learning Environment

by

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Creating a classroom environment that fosters a productive learning experience and engages students in the learning process is a complex endeavor. A classroom environment is dynamic and requires a unique synergy among students, teacher, classroom artifacts and events to achieve robust understanding and knowledge integration. This dissertation addresses this complex issue by developing, implementing, and investigating the simple machines learning environment (SIMALE) to support students' mechanical reasoning and understanding. SIMALE was designed to support reflection, collaborative learning, and to engage students in generative learning through multiple representations of concepts and successive experimentation and design activities. Two key components of the SIMALE are an original web-based software tool and hands-on Lego activities.

A research study consisting of three treatment groups was created to investigate the benefits of hands-on and web-based computer activities on students' analytic problem solving ability, drawing/modeling ability, and conceptual understanding. The study was conducted with two populations of students that represent a diverse group with respect to gender, ethnicity, academic achievement and social/economic status. One population of

students in this dissertation study participated from the Mathematics, Engineering, and Science Achievement (MESA) program that serves minorities and under-represented groups in science and mathematics. The second group was recruited from the Academic Talent Development Program (ATDP) that is an academically competitive outreach program offered through the University of California at Berkeley.

Results from this dissertation show success of the SIMALE along several dimensions. First, students in both populations achieved significant gains in analytic problem solving ability, drawing/modeling ability, and conceptual understanding. Second, significant differences that were found on pre-test measures were eliminated on post-test measures. Specifically, while female students scored significantly lower than males on the overall pre-tests they scored as well as males on the same post-test measures. MESA students also scored significantly lower than ATDP students on pre-test measures but both populations scored equally well on the post-tests. This dissertation has therefore shown the SIMALE to support a collaborative, reflective, and generative learning environment. Furthermore, the SIMALE clearly contributes to students' mechanical reasoning and understanding of simple machines concepts for a diverse population of students.