Coding Science Internships:

Broadening Participation in Computer Science by Positioning Coding as a Tool for Doing Science

Eric Greenwald
Lawrence Hall of Science
University of California, Berkeley
Berkeley, CA USA
eric.greenwald@berkeley.edu

Ari Krakowski
Lawrence Hall of Science
University of California, Berkeley
Berkeley, CA USA
akrakowski@berkeley.edu

ABSTRACT

Computational tools, and the computational thinking (CT) involved in their use, are pervasive in science, supporting and often transforming scientific understanding. Yet, longstanding disparities in access to learning opportunities means that CT's growing role risks deepening persistent inequities in STEM [2]. To address this problem, our team developed and studied two 10-lesson instructional units for middle school science classrooms, each designed to challenge persistent barriers to equitable participation in STEM. The units aim to position coding as a tool for doing science, and ultimately, encourage a broader range of students, and females in particular, to identify as programmers. Students who participated (n=391) in a recent study of the units demonstrated statistically significant learning gains, as measured on an external assessment of CT. Learning gains were particularly pronounced for female students. Findings suggest that students can develop CT through instruction that foregrounds science, and in ways that lead to more equitable outcomes.

KEYWORDS

Computational science; broadening participation; coding to learn

1 BACKGROUND

Integrating CT within core subjects shows promise for broadening access [1, 2], yet research is nascent. Needed is better understanding of how CT integration best serves underrepresented groups. To address this, we developed two 10-lesson *Coding Science Internship* units for integration within a school's core middle school science curriculum. The simulated internships immerse students in the computational work of scientists and seek to expand students' perceptions of the applications and value of computer programming. For the unit under study, students work collaboratively to program interactive scientific models of a coral reef ecosystem. The purpose of their models is to communicate to stakeholders how various threats affect coral reef health and how those threats may be mitigated. Our pedagogical framework grounds Resnick's *coding to learn* [3] within the construct of legitimate peripheral participation [4]. We instantiate the framework through a learning sequence in which students first apply scientific concepts to understand a digital simulation and its underlying code, then work toward more central participation as they apply newfound programming practices to improve and further develop the simulation as a scientific model.

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2 METHODS

Research seeks to understand what design features show promise for building student capacity, broadening participation, and supporting scalable CS + Science integration. Reported findings focus on pre/post changes in student performance on the *Assessment of Computational Thinking* [5] in a research trial with a diverse sample of 391 middle school science students.

3 FINDINGS

Students demonstrated significant learning gains pre- to post-instruction. For n=391 students, the mean gain on a 10pt scale was 0.353 ($p<.001$; effect size=0.20). Learning gains for female students were particularly pronounced (effect size =0.26). Further, a performance gap measured prior to instruction narrowed considerably by the end of instruction: a Tukey *post hoc* test revealed pre-instruction mean scores were significantly lower for female students (5.07 ± 1.75, $p = .015$) than for male students (5.65 ± 1.95), whereas the difference was much smaller post-instruction, and no longer statistically significant (5.52 ± 1.84 for females, compared to 5.86 ± 1.93 for males). Student and teacher interviews suggest learning experiences grounded in solving real-world problems was a key motivator for equitable engagement.

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