Project Summary

Recent years have seen a diversity of curricula designed to attract students to computer science. Media, robots, games, and other contexts have brought the field to life for many students [25,36,49,56]. Yet these and other innovative introductory courses are not designed to serve the distinct needs of students in the sciences, mathematics, and engineering disciplines. Although STEM students require increasingly sophisticated computational capabilities, their formal training in computation—if any—often focuses on a narrow range of applications to the exclusion of fundamental and widely transferable Computational Thinking (CT) concepts and skills.

This proposal's hypothesis is that the computational-thinking curricula for all STEM students can benefit from the insights gained from contextual "CS1" courses. Harvey Mudd College (HMC) has recently designed, deployed, and evaluated a breadth-first introductory CS1 curriculum with a STEM-themed context [15, 17]. This proposal seeks to turn that course inside-out, spawning a suite of computational thinking modules that can be flexibly composed into curricula for non-CS STEM students and pre-CS-majors alike. Instead of "another CS1," the result will be resources that span STEM-serving computational-thinking courses and provide a compelling introduction to core CT ideas and skills for students with a broad range of science and engineering interests.

Specifically, our objectives are to:

1. Design and assess rich and compelling course modules that can be assembled into introductory CT courses for a variety of audiences (high school, undergraduate, and graduate level) in different areas (e.g. computer science, biology, or engineering) and at different types of institutions (e.g. liberal-arts colleges and large universities). These modules will be problem-based, using STEM-motivated labs and assignments to develop and exercise major concepts.

2. Combine these modules to develop and deploy several prototype courses including introductory college computer science courses, an introductory college computation for biology course, a high school computation course, and a course for information technology graduate students.

3. Disseminate our modules and courses through (1) a structured deployment process that guides other schools (not directly involved in this project) in choosing appropriate modules for their contexts and (2) structured workshops, visits to other schools, and publications and talks at a number of education conferences and symposia.

Intellectual Merit: The proposed work will create a flexible, retargetable CT curriculum, grounded in but not limited by core CS topics, and aimed at students with a broad range of scientific and engineering interests. The PIs have extensive experience developing novel and engaging CS1 curricula for students *outside the CS major*: HMC's *CS for Scientists* course has proven successful at exciting students across STEM disciplines about how they can leverage computation in their chosen fields. Adapting this course's materials to a broad range of institutions is an important step in understanding how to develop the computational capabilities of all STEM students.

Broader Impact: This work will directly create CT curricula for five very different institutions: two large public universities, one of which serves a large minority population, one liberal arts college, one public high school and one graduate school. All five curricula will draw material from a flexible and modular set of resources that will create or inform CT courses far beyond this initial set of schools. Most importantly, these five CT courses will enable a thorough and cross-cutting assessment of the impact and relevance of CT for students throughout STEM disciplines. The approach has already shown significant improvement in increasing interest in computation among young women at Harvey Mudd College; this proposal's much wider assessment will determine how much these local successes transfer across a diversity of populations and institutions.