# Principles and Resources for Educators Integrating Computational Thinking into High School Science Courses (PREDICTS)

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## Abstract

As computing has become integral to the practice of science, technology, engineering, and mathematics (STEM), this STEM+Computing project seeks to address emerging challenges in computational STEM areas through the applied integration of computational thinking and computing activities within STEM teaching and learning in high school. This project will integrate computational thinking (CT) with biology and chemistry in high school science courses, and conduct research to generate knowledge about:

(1) How to create instructional experiences for all high school students that engage them in CT in their learning of science,

(2) What teachers require to effectively provide these experiences as a regular part of their science program, and

(3) How to measure student engagement in and learning of CT in the context of science.

This work is a collaboration between Horizon Research, Inc., a Chapel Hill (NC)-based educational research organization specializing in work related to STEM education, and the North Carolina School of Science and Mathematics (NCSSM), the nation's first state-supported residential school for STEM students. NCSSM has the largest high school program in the computational sciences in the country, with nine courses that include a survey course and computational courses in chemistry, physics, biology, medicine, nanotechnology, and digital humanities, along with two research courses in the computational sciences.

## Research Questions

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| How can computational thinking be operationalized in high school science courses? | • What are the design features of curricular modules that feasibly and effectively infuse computational thinking into high school science courses?<br>• What is an appropriate balance in designing experiences that use computational tools to support learning science content authentically through computing, but also structures the use of the tools to make them accessible to students and feasible to implement? |
| What do high school teachers need to understand and believe to promote computational thinking in their science courses and to teach science using computational thinking? | • What professional learning experiences develop needed understandings and beliefs?<br>• What support do classroom teachers need in order to effectively and efficiently integrate computational thinking into high school science courses? |
| How can computational thinking integrated into science instruction be rigorously measured in terms of students': | • opportunities to engage in and learn computational thinking?<br>• learning outcomes in computational thinking in the sciences? |

## Computational Science

Computational Science is a multidisciplinary field of science, designed to apply the technologies, techniques, and tools of computer science and mathematics to the study of challenging problems in sciences.

The Venn diagram shown in Figure 1 defines the relationship between science, computer science and applied mathematics. Computational Science lies at the intersection of those three disciplines. The term "science disciplines" is an inclusive term, representing not only traditional sciences (chemistry, physics, biology) but also disciplines such as finance, medicine, and the humanities.

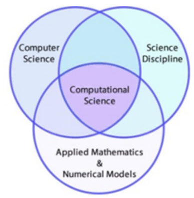



Figure 1: Computational Science Venn Diagram

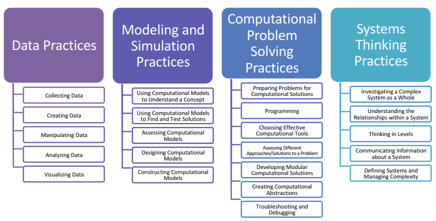
## Computational Thinking

Computational thinking is a way of solving problems, designing systems, and understanding human behavior that draws on concepts fundamental to computer science. To flourish in today's world, computational thinking has to be a fundamental part of the way people think and understand the world.[1]

In PREDICTS, our focus is on teaching science ideas using computational tools. The science claims that students make will be formed from reasoning about evidence provided by computational tools (computational evidence). Students will use CT practices to support science learning. Instruction will also make explicit why students are engaging in CT practices. The main taxonomy being used for the PREDICTS work comes from Weintrop and colleagues.[3] In this taxonomy, CT is viewed as using one or more practices from four overarching categories: data, modeling/simulation, computational problem solving, and systems thinking. Figure 2 shows the taxonomy.

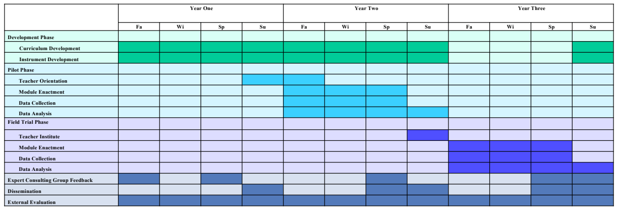
Figure 2: Computational Thinking in Mathematics and Science taxonomy

Weintrop et al., 2014




## Implementation

This exploratory integration research project will be implemented in three phases (development, pilot, and field trial) and will conduct mixed-methods studies of curriculum adaptation, teacher preparation and support, and measurement of student instructional experiences and outcomes.




## Development Phase

Create four curricular modules supporting CT in high school biology and chemistry.

Create two instruments to assess instructional opportunities to learn and engage in CT and to measure evidence of CT in student work.

The modules will encompass approximately one week of instruction, with an emphasis on addressing topics already required in chemistry or biology. Required mathematics is no higher than Algebra/Math 1.

## Pilot Phase

Engage veteran teachers who will pilot modules, provide feedback for the ongoing development phase, and identify preparation and supports other teachers will need.

Provide opportunities for the research team to observe instruction and collect portfolios of student work to develop and pilot assessment tools.

## Field Trial Phase

Select twelve teachers who will be prepared to implement the modules and receive targeted, ongoing support.

Provide opportunities for the research team to observe instruction and collect portfolios of student work to analyze using assessment tools.

## References

1. Center for Computational Thinking, Carnegie Mellon University, http://www.cs.cmu.edu/~CompThink/, accessed May 2018.
2. Weintrop, D., Orton, K., Horn, M., Beheshti, E., Trouille, L., Jona, K, & Wilensky, U. (2014). *Computational thinking in the science classroom: Preliminary findings from a blended curriculum.* Chicago, IL: Northwestern University

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