

The Value of Computational Thinking across Grade Levels 9-12 Project

VCTAL is developing a set of instructional modules and mini-modules for use in high school classrooms to help cultivate a facility with computational thinking in students across different grade levels and subject areas.



What is Computational Thinking? ISTE & CSTA say that “**Computational thinking** (CT) is a problem-solving process that includes (but is not limited to) the following characteristics:

- Formulating problems in a way that enables us to use a computer and other tools to help solve them
- Logically organizing and analyzing data
- Representing data through abstractions such as models and simulations
- Automating solutions through algorithmic thinking (a series of ordered steps)
- Identifying, analyzing, and implementing possible solutions with the goal of achieving the most efficient and effective combination of steps and resources
- Generalizing and transferring this problem solving process to a wide variety of problems”



VCTAL Activities

Developing, testing, and implementing an innovative mix of twelve one-week instructional modules for grades 9-12

Hosting summer workshops for students to assist authors in writing the modules and teachers in teaching them

Evaluating the influence of VCTAL materials on diverse students’ awareness of computational thinking opportunities and interest in related technical fields

Widely disseminating the materials we create

Sample Module Questions

- Is an electric car an economical choice?
- Where should you install new capacity in a network?
- Which patients will get hearts donated for transplants?
- Whom should the Dallas Cowboys draft in the next round?
- Where should you locate electric vehicle charging stations?
- Can two people figure out which of them is richer without revealing their wealth?



VCTAL Partners

- DIMACS, Rutgers University (PI: Midge Cozzens; co-PI: Rebecca Wright)
- Hobart and William Smith Colleges (co-PI: Paul Kehle)
- Consortium for Mathematics and its Applications COMAP (Solomon Garfunkel)
- Colorado State University (Len Albright)
- CSTA and partner schools in AK, MS, PA, MT, & SC



NSF Grant: DRL-1020201
PI: Margaret (Midge) Cozzens
midge6930@comcast.net



List of Modules

It's an Electrifying Idea! – explores whether it's time to buy an electric car by examining its cost to own and convenience to operate. The module has two stand-alone parts using, respectively, spreadsheets to examine cost issues and graph models to explore range limits and charging requirements.

Heart Transplants and the NFL Draft – engages students in developing ranking procedures for both heart transplantation and the NFL draft. Students examine difficulties unique to each context, identify similarities and differences, and consider how to measure the “success” of their rankings.

Network Capacity Expansion and Utilization – uses networks familiar to students (text messaging, cell phone, Internet) as motivation to model capacity and demand in simple networks. Students run simulations and come to understand the difference between average and peak demand, how they impact the network, and the costs associated with adding new capacity.

Privacy: Do You Know What They Know about You? – examines how people can use and enjoy technology such as social networks (like Facebook and Twitter) while still having some kind of privacy. Through a series of case studies, students analyze data collection and sharing strategies with a focus on the interplay among technology, society, and policy.



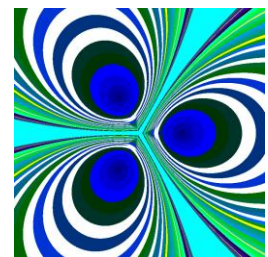
Tomography: a Geometric and Computational Approach – introduces the science of examining internal structure with external measurements. Students perform activities in which they try to determine what is inside some object, figure out how to measure components inside, and suggest how these measurements can be made more precise.

Foolproof Codes and Ciphers – brings students from methods for encrypting messages during the time of Caesar to the modern RSA method. Students compare a variety of codes for information transmission and think about how to encrypt information so that it can later be decrypted. Students learn about the mathematics underlying the RSA method and its implementation.

Fair and Stable Matching – explores how to match people (or objects) from two distinct sets, when each have preferences on the other. Students learn about stable matchings, consider fairness in selecting among potential stable solutions, and observe real-life examples that figured into the 2012 Nobel Prize.

Polynomiography & Art – encourages computational thinking through one of the most basic and fundamental tasks in sciences and mathematics: solving a polynomial equation. Students learn about the notion of iteration by experimenting with algorithms for polynomial root finding.

Competition or Collusion – involves students in playing simple games to observe and describe their decision-making processes during play. Students extend these ideas to model real-life situations using the concepts of game theory, and they develop algorithms for optimal decision-making in certain settings.



Analysis of Games – challenges students to find efficient strategies for analyzing the quality of moves being played in a game and searching for the best moves given the current state of the game.

Streaming Information – introduces students to the issues, methods, and challenges in successfully transmitting information. Topics include error detection, error correction, data authentication, data compression, and efficient transmission.

Recursive Thinking – encourages students to think recursively by investigating and inventing their own recursive definitions, such as the definition of $n!$. They consider functions defined recursively, such as parsers in computer science, and recursion in algorithms like those for dynamic programming.

