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.

**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?

**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 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

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Modules in Testing

It’s an Electrifying Idea!
This module 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 that can be used together or separately. The first component examines the cost of owning an electric car relative to a traditional hybrid or a gasoline-powered car. Students learn the basics of building a cost model, making assumptions, and confronting uncertainty through scenario analysis with a spreadsheet. The second component looks at convenience by asking the question, “Can I get there from here?” In so doing, it introduces the correspondence between maps and graphs, relates graph connectivity to vehicle range, and explores locating charging stations to ensure that feasible routes exist. This module is appropriate for mathematics classes or other types of classes that address technology in society, business, or life skills.

Heart Transplants, the NFL Draft, and Computational Thinking
When a group of people must decide on whom to select out of a group of eligible candidates, how do they decide? Who should have input into the decision?

- Given all the people eligible for a heart transplant how do you decide who gets one?
- Given all the people eligible to be CEO for a company, how do you decide?
- How does a professional sports team choose a player in the draft and how does a player maximize his position? How does the NFL promote fairness among teams?

The students develop ranking procedures for both heart transplantation and the NFL draft. They examine the similarities and the differences, and they look at difficulties unique to each context. They consider how to the measure “success” of their rankings, and compare various alternatives based on spreadsheets and solutions from other members of their class. This module is appropriate for mathematics, computer science, and social studies classes in grades 9-12.

Network Capacity Expansion and Utilization
This module uses networks familiar to students (text messaging, cell phone, Internet) as a motivating point to model capacity and demand in simple networks, such as school hallways, and then builds on this to consider more complicated networks. Students develop the skills and perspectives used in modeling real-world situations using networks as an example. They simulate the likelihood of congestion delay using rolls of dice (and later Excel spreadsheets) to consider issues of capacity when constructing networks and/or routes. Students come to understand the difference between average and peak demand and the costs associated with adding new capacity. As students run simulations many times, and as they look at more complex simulations, they see the essential role that computers play in this approach. This module is appropriate for mathematics and computer science classes grades 11-12.

Internet Privacy
How can people 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 explore uses of data that are intrinsic to the value that users gain from a social network site, as well as uses of data that are valuable for business resource (such as use for advertising). Students evaluate the case studies to determine the effects on the overall usefulness of the site to its users and to its owners based on a variety of privacy policies and privacy policy settings. A simple example of computing without revealing information is another case study (e.g., the pricing of crops without revealing the quantities of crops grown). The module incorporates critical analysis of data collection and sharing strategies, management of interfaces, and a focus on the interplay among technology, society, and policy. This module is appropriate for social studies, media studies, and computer science classes in grades 9-12.

Modules under Development

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