Embedding computer science in science classes-
Modeling and Simulation

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Outline of today’s presentation

• Science in the 21st Century
• NRC Framework’s “Scientific Practice” dimension
  ▫ Key points and what they mean
    • Models, Computer models/simulation, Data analysis
    • Computational thinking
• Programs that integrate Modeling & Simulation
• How they do it – computational science cycle
• Examples of how they address NGSS’ Scientific Practice dimension.
• Why “USING models” is not enough.
Computational Thinking

Skills, habits and approaches that are integral to solving problems using computers, developing models and performing simulations

Three Pillars of Computational Thinking

- **Abstraction** – strip down a problem
- **Automation** – repetitive tasks
- **Analysis** – validate abstractions
Computational Thinking

Computer Modeling and Simulation:
- Agent based modeling
- Stochastic modeling
- Monte Carlo simulation
- Systems dynamics modeling

Computational Thinking:
- Abstraction
- Automation
- Analysis
NRC Framework & NGSS Structure:

Framework:
“Vision” document

Standards:
Every standard has three dimensions:
1. Science/Engineering practices (SEPs) = practice
2. Disciplinary core ideas (DCIs) = content
3. Cross-cutting concepts (CCs) = themes
Framework’s 8 Scientific practices

1. Asking questions and defining problems
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using math and computational thinking
6. Constructing explanations / solutions
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating info.
What’s new?

A) Content and practice are intertwined. (Greater emphasis on “learn and do”, and learn by doing, rather than on rote memorization.)

B) Practice includes the use, creation and analysis of computer models and simulations in STEM inquiry and engineering design cycle.

C) Practice includes computational thinking

A) No prescribed ordering of practices
Framework concepts

• Mathematics and computational tools are central to science and engineering.

• Aspects of computational thinking and statistical thinking must be understood and applied in learning about the sciences.

• Students should learn to use mathematics, computational models and computational and statistical thinking for scientific inquiry and data analysis.
Goals relating to developing and using models  (NRC Framework, p. 50)

By grade 12, students should be able to:

• Represent and explain phenomena with multiple types of models.
• Discuss the limitations and precision of a model ...
• Refine a model ....
• Use computer simulations as a tool for understanding aspects of a system....
• Make and use a model to test a design and to compare the effectiveness of different design solutions.
Goals related to using computational and mathematical tools for data analysis (NRC Framework, p. 56)

By grade 12, students should be able to:

- Recognize that computer simulations are built on mathematical models that incorporate underlying assumptions about the phenomena or systems being studied.
- Use simple test cases of mathematical expressions, computer programs, or simulations—that is, compare their outcomes with what is known about the real world—to see if they “make sense.”
- Use grade-level appropriate understanding of mathematics and statistics in analyzing data.
The Computational Science Cycle

1. Asking questions / defining problems
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using math and computational thinking
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7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating info.
do experiments & get data

compare computer model data to real-world data

computer model
Three NM programs that explore STEM topics to teach modeling and simulation using the computational science cycle:

- Project GUTS
- New Mexico Computer Science for All
- Supercomputing Challenge
MIDDLE SCHOOL PROGRAMS

Project GUTS offers:

Afterschool clubs for middle school students in NM

*Elective classes in some middle schools

Fieldtrips/Conferences and Student Roundtables
Project GUTS Framework:

- Use-Modify-Create trajectory
- Place-based education
- Studying local phenomena as complex systems
  ex) Spread of disease, traffic patterns, pollution, ecosystems, emergency egress, shared resources and sustainability, social networks, and opinion dynamics
- Near-peer mentoring
- Meeting developmentally appropriate needs: comfortable context, program flexibility, and social environment.
Rich Computational Tools

StarLogo Nova....
We use Starlogo Nova to explore Emergent and complex systems

Users create simulations by writing simple rules for individual “agents”

No sophisticated mathematics or advanced programming skills are required

* Free and web based
Use-Modify-Create progression

USE

MODIFY

CREATE
National Partnership

Project GUTS / Code.org CS in Science curriculum (available on Code.org site)

• Introductory Module (6 days or 300 minutes)
• Modules for Earth, Life & Physical Science (5 days or 250 minutes)
New Mexico Computer Science for All

- A comprehensive year-long teacher professional development program in Computer Science.

[Logos of Computing Education for the 21st Century (CE21), NSF, The University of New Mexico, Santa Fe Institute, and Supercomputing Challenge]
What is NM-CSforAll?

- The comprehensive teacher professional development program in Computer Science offers:
  - Professional Development for teachers via a UNM Computer Science course offered online.
  - Practicum: Computer Science course offered for high school students.
NM-CSforAll’s goals

- The program’s goals are to:
  - Prepare high school STEM teachers to be future CS teachers.
  - Create pathways for implementation of CS classes within NM high schools.
  - Increase the number and diversity of students taking CS classes in NM high schools.
About the online course:

• Features the Big Ideas of CS from “CS Principles” framework.

• Uses Modeling & Simulation as an introduction to Computer Science

• Demonstrates the wide applicability of CS
What is the practicum?

- Serve as **learning coach** during the lab portion of Fall 2014 dual credit UNM CS108L hybrid course for HS students.

- Offered as a **regular school day class** within high schools.

- Use pedagogy and best practices for engaging and retaining underrepresented students in computing.
What kinds of support?

- Regional facilitators
  - Face to face regional workshops (3 half-day)
  - Online facilitation

- Collection of guided lessons (ppt & video) and how-to’s.

- Online Professional Development network (Community of Practice)
Benefits for teachers

- Three UNM graduate credits for completion of CS590.
- Stipend for participation in PD workshops.
- Be part a national effort to reinstate CS education in high school.
- Become part of our vibrant learning and professional community!
Benefits for students:

• Take an introductory level CS course (proposed by the College Board as a precursor to the AP CS A course).

• Juniors and Seniors can receive dual credit and fulfill a graduation requirement. (dual-credit, AP, honors)

• For all: Great preparation for AP CS A and to compete in the Supercomputing Challenge.
Why is NM-CSforAll important?

• Computer Science is the foundation of today’s innovation economy.

• Important beyond the IT sector
  • Biology, chemistry, physics,...
  • Manufacturing, healthcare, retail, weather forecasting, arts, financial services sector.

• Critical thinking and computational thinking.

• Employable highly sought-after skills!
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COMPUTER SCIENCE
EDUCATION
in New Mexico

Computer Science For ALL
If you are interested in joining this summer’s CS590 course through UNM, you’ll need to sign up today. However, space is limited and there will be a selection process. Maureen Psaila-Dombrowski will be in touch with you next week. Class materials are open starting June 1 and finishes by July 20th.
Now it’s time for us to do some Coding!