Computational Thinking from a Disciplinary Perspective

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What do you think?

Is CT best developed through programming?
Is CT best developed when integrated with other content?
Pick one that best describes you.

- Non-CS Educator
- CS and/or Technology Educator
- Education Researcher
- School/School System Administrator/Leader
- Parent
- Business/Industry Representative
- Other (write in?)
How are you involved in an effort to help students develop CT skills?

I’m not, but interested in learning more.
I’m a disciplinary teacher integrating CT into a content area.
I teach CT within a computer science course / class.
I provide support to teachers integrating CT.
I am a CT champion.
I provide resources to teachers in my school/system.
Workshop to Develop an Interdisciplinary Framework for Integrating CT in K-12 Education

Workshop Goals
• Draft a framework defining computational thinking from a disciplinary perspective.
• Develop assessment recommendations or new research questions to close the gap between what CT assessments are already developed/in progress and assessments needed to measure CT from a disciplinary perspective.
Structure, Advisors and Participants

Workshop 1 (August 2017): Framework Building
Workshops 2 (November 2017): CT Assessment

Advisors: Irene Lee (MIT), Shuchi Grover (SRI/ACT), Fred Martin (UMass Lowell), Michael Evans (NC State)

Participants: 54 including 31 researchers, 18 practitioners, 3 participant observers, 2 staff. (13 from colleges/universities, 15 from schools, 15 from non-profits, 1 from business, 3 from foundations including NSF).
How we got to the Elements

Reviewed materials from:

• participants including background information on their projects and examples of curriculum and activities that illustrated CT in action in their classrooms.
• researchers including aspects of CT they research in K12 education.

Discussed/analyzed CT classroom activities by grade and subject to identify common elements that would identify what could be difficult to do without using CT.
How we got to the Elements

Bridging between CT as it is currently integrated in K-12 and professional practices involving CT in scientific workplaces.

Explored what CT looks like in practice in scientific work environments (with attention to techniques and practices that could not be performed without CT)
CT integrated fields
- Bioinformatics
- Astrophysics
- Computational Neuroscience
- Computational Social Science
- Computational Chemistry
- Computational Biology
- Computational Archeology
- Computational Economics
- Computational History

CT Integration Elements (Powerful practices in CT integrated fields)

CT skills (DLCS)
- Abstraction
- Algorithms
- Programming / Development
- Data collection & analysis
- Modeling & Simulation
CT in Practice in the Scientific Workplace

Using multiple models (ensemble forecasting) to predict behavior of complex systems.
Coming up with new representations that can be manipulated easily using a computer.

http://www.daylight.com/meetings/summerschool98/course/dave/smiles-intro.html
CT in Practice in the Scientific Workplace

Genome sequencing and data analysis.

https://www.cdc.gov/pulsenet/pathogens/wgs.html
Designing processes to achieve high performance computing workflows.

Task Decomposition: Each processor does a subset of the task.

Domain Decomposition: Each processor does the same task on a different input set.

CT in Practice in the Scientific Workplace

https://computing.llnl.gov/tutorials/parallel_comp/
CT in Practice in the Scientific Workplace

Crowdsourcing data for regional water management.

http://www.mdpi.com/2071-1050/7/1/441/htm
CT in Practice in the Scientific Workplace

Machine Learning

Input → Feature extraction → Classification → Output

CT Within Disciplines

• Understand (complex) systems
• Innovate with computational representations.
• Design solutions that leverage computational power/resources
• Engage in collective sense making around data.
• Understand potential consequences of actions.
When the CT skills below are understood/mastered, one has (some of) the necessary computational basis to formulate problems and their solutions so their solutions can be carried out by a computational agent.
Understand Complex Systems

- Study complex systems using computer modeling and simulation.
- Run multiple trials to see the impact of randomness and uncertainty.
- Use multiple models and compare their outcomes.
- Analyze models for validity.
Innovate with Computational Representations

- Compare methods used to represent information.
- Develop your own encodings/languages for different purposes.
- Test to see if your encodings are unique and computer readable.
Design solutions that leverage computational power / resources

- break down tasks into smaller tasks that can be performed sequentially (as in an assembly line).
- decompose data sets into smaller data sets that can be processed in parallel.
- optimize processing time for a given task and data set.
Engage in Collective Sense Making

- Crowdsource data.
- Look for global patterns and local variation.
- Have students run simulations with different input values then aggregate results.
Understand potential consequences

- Cause and effect
- Model validity
- Variation in outcome
- Unitended consequences
- Bias in prediction
- Harmful consequences
Progress: CT through a Disciplinary Lens

- Elements reworked to bridge more traditional CT & disciplines.
  1) Understand systems
  2) Innovate with computational representations
  3) Design solutions that leverage computational power/resources
  4) Engage in collective sense making around data
  5) Understand potential consequence of actions
Q&A
THANK YOU

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