Computational Thinking

The VT Community

web site: www.cs.vt.edu/~kafura/CS6604

Virginia Tech

Today's Class

- Meet faculty and researchers
  - From a variety of knowledge domains
  - With a variety of perspectives and experiences related to computational thinking
- Help build the community with the knowledge and interest critical to the university initiative

Discussion

- Who are you?
- Why are you interested in computational thinking?
- What do you think computational thinking is?
- What experiences have you had related to computational thinking?

Framing a definition

- Computational thinking is a cognitive ability characterized by creative work using information susceptible to automation.
  - Cognitive – a fundamental mental ability, not just skill in tool use
  - Information+automation –
    - what distinguishes computational thinking from other ways of thinking
    - Need not be automated, but must be automat**able**
    - Automation provided by traditional computing devices, biological systems, quantum computers, …
- The ability is derived from sufficient mastery of a conceptual framework. The conceptual framework includes:
  - abstraction
  - algorithms
  - state, state space,…
  - …

Views of CT

- "…computational thinking helps us to systematically and efficiently process information and tasks." [Lu 2009]
- "CT is … about developing the full set of mental tools necessary to effectively use computing to solve complex human problems." [Lu 2009]
- "We consider computational thinking to be the thought processes involved in formulating problems so their solutions can be represented as computational steps and algorithms." [Aho 2012]

Role/place of programming

- "…efforts must be made to lay the foundations of CT long before students experience their first programming language." [Lu 2009]
- "Programming should not, however, be essential in the teaching of computational thinking, nor should knowledge of programming be necessary to proclaim literacy in basic computer science." [Lu 2009]

A Computational Thinking Language

- "…vocabularies and symbols that can be used to annotate and describe computation and abstraction, suggest information and execution, and provide notation around which semantic understanding of computational processes can be hung." [Lu 2009]
- Perspective
  - developing terminology (i.e., a language) to describe ideas related to computational thinking in K12
  - Language is a precursor to formal or focused study of computational ideas and programming languages
- What about graphical languages that remove lexical/syntactic detail?

Examples

Level	Example	CT Concept
3rd Grade	Multiplication via repeated addition	iteration efficiency
	Sentence ordering	state, search space, pruning
	Graph comparisons	representation matters
	Assembly line	throughput
Middle school	Finding square roots	algorithm, efficiency, representation
	Diagramming sentences	grammars, recursion, non-determinism

Computational Models

- "…the nature of systems exhibiting computational behavior is varied and the term computation means different things to different people…" [Aho 2012]
- "Rather than talking about a vague notion of "computation," my suggestion is to use the term in conjunction with a well-defined model of computation whose semantics is clear…" [Aho 2012]
- "A model of computation is a mathematical abstraction of a computing system." [Aho 2012]
- Forces at play
  - scale/ubiquity of computing – making simple models too limited
  - parallel/concurrent architectures – making sequential models inappropriate
  - breadth of phenomenon (e.g., biological models)
- Examples:
  - Turing machines – sequential computation
  - Actors, Petri nets. pi calculus – concurrent computation

Discussion

- What does this mean for the university level?
- Language for CT
  - Need to define consistent terminology across courses/curriculum
  - How are these terms differentiated/related to similar terms in various disciplines?
  - How are these terms introduced?
    - By context
    - By explicit/separate presentation
  - Assessment
    - How is the adoption/understanding of the terminology assessed
    - Is the terminology assessed separately from the use of CT in creative work?
- Models for CT
  - What model of computation do students understand?
  - What model(s) do they need to know?
  - Is there a single model for all?

References

- [Lu 2009] Lu, J.J. and G.H.L. Fletcher, *Thinking About Computational Thinking*, in *SIGCSE'09*. 2009: Chattanooga, TN, USA.
- [Aho 2012] Aho, A., *Computation and Computational Thinking.* The Computer Journal, 2012. **56**(7): p. 832-835.