COMPSCI 1JC3
Introduction to Computational Thinking
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01 What is Computational Thinking?

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Admin

- Use only McMaster email to communicate with the instructional staff.
- Course material and messages are distributed on Avenue.
- iClicker questions will be counted starting next week.
- M&Ms start next week.
- Office hours: To see me please send me a note with times.
- Are there any questions?

Advice

1. Read carefully and fully all the course material!
2. Attend all the lectures, discussion sessions, and tutorials!
3. Come prepared!
4. Take notes!

Review

1. What computing is?
   - The development and use of computer hardware and software to solve problems, manage information, create smart products, explore our world, and connect to other people.

2. What computational thinking is?
   - Thinking inspired, supported, or enabled by computing.

Kinds of Thinking

- There are many kinds of thinking.
- Examples include:
  - Historical thinking.
  - Political thinking.
  - Business thinking.
  - Mathematical thinking.
  - Engineering thinking.
  - Scientific thinking.
  - Artistic thinking.

Mathematical Thinking

- Mathematics is a process for understanding the mathematical aspects of the world consisting of the following intertwined activities:
  1. Mathematical models are created that represent mathematical aspects of the world.
     - The nonmathematical aspects are abstracted away.
  2. The models are explored by stating and proving conjectures, performing computation, creating and studying visual representations, and studying examples of the models.
  3. The models are organized and interconnected.
  4. The models are presented in a narration form.
- Mathematical thinking is the thinking underlying the mathematics process.

Scientific Thinking

- Science is the systematic study of the world through observation and experiment.
- Scientific thinking is centered on:
  1. The scientific method as a process of hypothesis formation and experimentation.
  2. The formation of knowledge on the basis of empirical evidence and deductive thinking.

Engineering Thinking

- Engineering is the systematic and rational application of knowledge — particularly mathematical and scientific knowledge — to solve problems and create things for the benefit of society.
- Engineering thinking is thus concerned with:
  1. Developing and employing best practice.
  2. Understanding problems and products in terms of systems.
  3. Using requirements to drive product development.
  4. Maintaining public safety and security.

Artistic Thinking

- Art is the production of artifacts that express beauty or salient aspects of the world and human existence.
- Artistic thinking is thinking that fosters the creation of art and includes:
  1. Finding inspiration in nature, ideas, past events, imagination, and other artwork.
  2. Looking for new ideas and experiences.
  3. Imposing restrictions to focus creativity.

Computational Thinking

- Developing computational thinking starts with understanding computing.
- Since computing includes mathematics, engineering, science, and design, computational thinking includes:
  1. Mathematical thinking.
  2. Engineering thinking.
  3. Scientific thinking.
  4. Artistic thinking.
- See Jeannette Wing's seminal 2006 paper "Computational Thinking".

Fundamental Questions of Computational Thinking

- The fundamental question of computational thinking:

  What can — and cannot — be done with computing?

- This question divides into two questions:
  1. What are the theoretical limits of computing?
  2. What are the practical limits computing?

Limits on What can be Computed (iClicker)

Are there any theoretical limits on what can be computed?

A. Yes.
B. No.

Who was Gottfried Leibniz? (iClicker)

Who was Gottfried Leibniz?

A. A great philosopher with an optimistic view of the world.

B. A mathematician who invented calculus.

C. One of the first great computer scientists.

D. One of the first great computer engineers.

E. A brilliant polymath.

Gottfried Leibniz was a Brilliant Polymath

- Gottfried Leibniz (1646–1716) was a German polymath of almost unrivaled brilliance.
- Trained in philosophy and law, he made major contributions in many areas.
- He developed calculus (1684) independently of Newton.
- He was a great computer scientist and engineer who anticipated many of the ideas of modern computing.
  - ▸ Developed the binary number system.
  - ▸ Invented the Staffelwalze (Stepped Reckoner), a machine that could do addition, subtraction, multiplication, division, and square roots.
- His motto was Calculemus! (Latin for "Let us calculate!").

Leibniz was a Fantastic Computational Thinker!

- He postulated the characteristica universalis, a universal language in which all scientific ideas could be expressed.
- He also postulated the calculus ratiocinator, a computer that could compute the truth or falsity of statements expressed in the characteristica universalis.
- Is a calculus ratiocinator theoretically possible?
  - ▸ No!
  - ▸ But this question was left unanswered for over 200 years — until Alonzo Church and Alan Turing showed independently in 1936 that there are undecidable decision problems!
  - ▸ The work of Church and Turing was heavily influence by Kurt Gödel's work on the incompleteness theorem.