計算思維的

重要性和推廣

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什麼是計算思維

- *Computational thinking* (CT) is a mental skill
- To apply fundamental concepts and reasoning, derived from modern digital computers and computer science, in all areas, including day-to-day activities.
- CT is thinking inspired by an understanding of computers and information technologies, the advantages, limitations, and problems they bring.
- CT also encourages us to keep asking questions like: "*What if we automate this?*", "*What instructions and precautions would we need if we were asking young children to do this?*", "*How efficient is this?*", and "*What can go wrong with this?*".

什麼不是計算思維

計算思維專治:

- 感性思維; 跳躍思維
- 忽略細節; 如意算盤
- 不顧因果; 本末倒置
- 掛一漏萬; 一團漿糊
- 知錯不改; 望文生意
- 以言舉人; 以人廢言
- 一問三不知

誰要學計算思維

In short, everyone!

- Everyone who wants to be a citizen of the digital world
- Everyone who wants to take full advantage of modern information technologies
- Everyone who wants to be more efficient and effective
- Everyone who wants to avoid pitfalls, guard against failure
- Everyone who wants to communicate and cooperate with others efficiently and smoothly

計算思維的內容

Important aspects of CT include

- Simplification through abstraction
- Iteration and recursion
- An eye and a mind for details
- Precision in communication
- Logical deductions
- Breaking out of the box
- Anticipating problems

何来計算思維

雞和蛋的問題

- Which comes first, “計算” 還是 “計算思維”?
- 計算思維 surely must include ideas and techniques, from other disciplines as well as the long history of human civilization, that contributed to the development, refinements, and breakthroughs in computing.
- 但是, computer science has also generated many unique concepts, techniques, and problem solving ideas.
- Computing has given rise to a digital ecosystem, called *cyberspace*, that includes us all.

如何學計算思維

CT inspired by different aspects of computing

- Symbols and meaning
- Logic and logical control
- Iteration and recursion
- Problem solving, algorithms, design, and analysis
- Processes, states, cooperation and coordination
- Programming,
- Networking,
- Protocols,
- User interfaces and API

- Data organization and processing, data as source of knowledge
- Privacy and security
- Advantages, applications, development, capabilities, and limitations of computing

計算思維的反例

Hurricane Sandy (2012) is one of the deadliest and most destructive hurricanes in US history. The hurricane caused close to **$62 billion** in damage in the United States

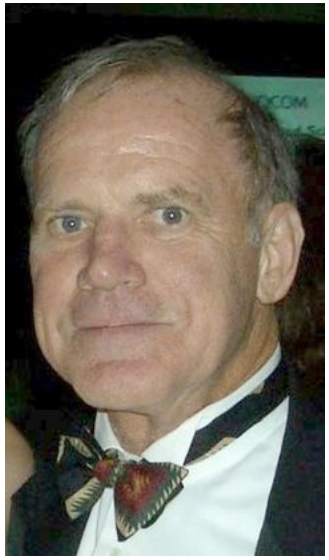
With CT at multiple levels, dare we say that many of the disasters from Sandy might be substantially reduced.

- The New York City subway entrances and air vents are at street level. What if streets are flooded? What if flood water enters the subway?
- What if we need to fight fires in a flooded area? Do we have fire boats in addition to fire trucks? Do we have firefighters trained for boats?
- Most portable emergency power generators run on gasoline. What

happens if gas runs out and gas stations are flooded?

- What if drinking water supply stops? Can we provide emergency water from fire hydrants? In that case, can we use a mobile contraption that connects to a hydrant, purifies the water, and provides multiple faucets?
- What if emergency power generators are flooded? Should we waterproof generators in designated at-risk buildings?
- What if cell towers lose power? How hard is it to deploy airborne (drone?) cell relays in an emergency?
- What if we simulate storm damage with computer modeling and find out ahead of time what to prepare for?

計算思維的例子



- The *polymerase chain reaction* (聚合酶鏈反應, P.C.R.)
- A technique in molecular biology to generate thousands to millions of copies of a particular DNA sequence.
- Invented by Dr. Kary Mullis in 1983. Won 1993 Nobel Prize in Chemistry .

In recounting his invention, Kary Mullis wrote in his book *Dancing Naked in the Mind Field*:

- I knew computer programming, and from that I understood the power of a reiterative mathematical procedure.
- If the process is multiplication by two, then the result of many cycles is an exponential increase in the value of the original number: 2 becomes 4 becomes 8 becomes 16 becomes 32 and so on.
- If I could arrange for a short synthetic piece of DNA to find a particular sequence and then start a process whereby that sequence would reproduce itself over and over, then I would be close to solving my problem.

- At the time of the invention, the “polymerase” and other related DNA duplication techniques were already known.
- It was the “chain reaction” part that was missing.
- We have Dr. Mullis and his computational thinking to thank for the invention.

And what a significant invention!

- The *New York Times* described it as "highly original and significant, virtually dividing biology into the two epochs of before P.C.R. and after P.C.R."
- P.C.R., together with computing, enabled the Human Genome Project
- Still need more convincing? Just ask the Innocence Project or any guiltless person freed from jail due to genetic fingerprinting.

從計算到計算思維

Learning computing help gain 計算思維:

- Gain 計算思維 from a better understanding of computing
- Gain 計算思維 from what computing can do for us
- Gain 計算思維 from the speed, power, and convenience computing gives us (千里眼, 順風耳, 光電子速度, 大記憶, 過目不忘, 明察秋毫)
- Gain 計算思維 from algorithms and programming in computing

Unlike 汽車思維, 計算思維 requires more teaching and learning.

計算思維的推廣

- 有計劃, 有系統, 和多方面的
- 從大專, 高中, 初中, 到小學
- 廣泛宣傳，在社會各階層, 使之成爲一種文化風氣和時尚
- 足夠的資源，人才，資金
- 爲學生和社會大眾, 創建良好適用的教材
- 使用媒體，節目, 遊戲, 競賽, 來提倡
- 利用萬維網和互聯網, 來普及和推廣

計算思維教材

- 從大專開始
- 從非計算機專業學生開始
- 相對完整而全面的, 一學期的教科書, 教師和學生馬上可用
- 深入淺出, 理解和思維並重, 理論與實踐並重
- 啓發思維, 易懂實用 –其他專業和日常生活
- 兼容中國文化與民情
- 在 Web 上提供互動, 有趣和有用的多媒體內容

計算思維積極行動

計算思維新字眼

- ***計算化*** *(computize)*

  定义：计算化，动词。应用计算思维来考虑，分析，设计，阐述，以求实现目标，解决问题.

- ***乏算*** *(failure to computize)*

計算思維的理想

人人追求計算化:

- 人人, 思想慎密, 滴水不漏
- 人人, 客觀冷静, 腳踏實地
- 人人, 邏輯清晰, 因果分明
- 人人, 精準互動, 可靠高效
- 人人, 三人吾師, 隨時進步

謝謝大家

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- New textbook:
  From Computing to Computational Thinking
  computize.org

- 敬請多多指教