Fundamentally Fixing Maths Education

Roadmap to Computational Thinking for the AI age

Day job: build the best maths/computationtech »







Day job: deploy maths for everyone

Stop Image contents FacialGender FacialAge FacialExpression

Day job: Computation for Everyone \implies smart automation Extra job: Everyone for Computation

\Rightarrow computationalthinking

Steve Jobs (1988):

"Mathematicawill revolutionize the teaching and learning of maths by focusing on the prose of mathematics without getting lost in the grammar." The real world changed. How should education react? Changed how? UbiquitousComputation

High-levelcomputationnow applicable everywhere,eg:

Always (Maths) Physics Accounting Newlyconceived Programming DataScience SocialMedia Finance New to computation Biosciences Historyand archeology Medicine(includingpandemicresponse) Sports Agriculture Marketingand business

Example: Biology

GenomeLookup["

Key Computational subfields... Data Science Coding ...but not whole picture

Core human skill: ComputationalThinking

Manifested by maths education...?

Maths education

Achieving data literacy, data science? Promoting logical thought? Optimising economic results/jobs? ...Developing computational thinking? Maths education crisis: 80% wrong subject?

Key difference: Computers

"In real-worldmath, computers do almostall the calculating; in educationalmath, people do almostall the calculating"

Why learn maths?

Everyone for "maths"?

Key reasons for the "right maths":1. Technical jobs2. Everyday living3. Logical mind training

Value-add Subsistence Survival

CT/mathsprocess?

- 1. **DEFINE** QUESTIONS
- 2. **ABSTRACT** TO COMPUTABLE FORM (real world → abstract)
- 3. **COMPUTE** ANSWERS
- 4. INTERPRET RESULTS (abstract → real world)

Use computers for...

1. **DEFINE** QUESTIONS

2. ABSTRACT TO COMPUTABLE FORM (real world → abstract)

3. **COMPUTE** ANSWERS

4. INTERPRET RESULTS (abstract → real world)

Use humans for...

1. **DEFINE** QUESTIONS

2. ABSTRACT TO COMPUTABLE FORM (real world → abstract)

3. COMPUTE ANSWERS

4. INTERPRET RESULTS (abstract → real world)

CT/Maths:problem-solvingprocess



Solve[
$$\{x + 2 = 2y, y - x = 5\}, \{x, y\}$$
]

Today's maths education headings [About hand-calculating]

Similartriangles Calculatethislongdivision Completingthesquare Invertingmatrices SimplifyingSurdsandRecurringDecimals Solvingsimultaneouœquations Thechainrule

Tomorrow's CT/mathheadings [Contextualproblemsneedingwholeprocess]

What's the perfectpasswordfor your login? Am I normal? ShouldI insure? How do I design controls for my game? Are our incentives working? How do we evaluateour social mediae ffectivenes *?* Is a fraudoccurring? How much can you compress photos, video or music before you notice? By how many levels of friends are we separated on Facebook? What's a beautiful shape? Remove the computer... \Rightarrow remove the context

Remove the computer... \Rightarrow different computational toolset \Rightarrow different subject



Example problem: can I spot a cheat?

Count: 191 data points

Modernalgorithmichinking/datascienceideas;onlypossibleifcomputer-based

Imagine

Taking this methodology, adding 30 years of the fullest knowledge of use of math, top tech, expertise and building this into a brand new **Core ComputationalCurriculum** that ... ASSUMESCOMPUTERSEXIST...

New ComputationalCurriculum What to deliver?

Actual learning materials for teacher and student... ... to map the curriculum

Directed to modern outcomes

Tethered to representative assessments

The path to creating computational problem solvers **Directed learning** Guided learning Independent problem solving Modules Problems Projects Support and guidance at every step Support available when needed Student determines of the pre-defined solution's track to stay on a suitable path their own independent path

Building out since 2010: computerbasedmath.org



"Build a core computational curriculum that assumes computers exist"

First detailed proposal for fundamental change



Part I: The Problem

- 1 | Maths v. Maths
- 2 | Why Should Everyone Learn Maths?
- 3 | Maths and Computation in Today's World
- 4 | The 4-Step Maths/Computational Thinking Process
- 5 | Hand Calculating: Not the Essence of Maths

Part II: The Fix

- 6 | 'Thinking' Outcomes
- 7 | Defining the Core Computational Subject
- 8 | New Subject, New Pedagogy?
- 9| What to Deliver? How to Build It?

Part III: Achieving Change

- 10 | Objections to Computer-Based Core Computational Education
- 11 | Roadmap for Change
- 12 | Is Computation for Everything?
- 13 | What's Surprised Me on This Journey so Far
- 14 | Call to Action

Example module: How fast can I cycle...?

Example projects: (Independentproblem solving)



New ComputationalCurriculum Right Outcomes» Right assessments

Outcomes: must engender Al-age "Thinking"

Abstractionof thinkingtechniques Hybrid human-Almanagement Intertwiningcreativityand process How do piece together: Outcomes, contexts, process

The path to creating computational problem solvers



New ComputationalCurriculum How to build?

Will traditionalbuild-processwork?

Reverse Engineer: Use actual problems to scope curriculum

Even we at Wolfram can't predict what's needed... Much tougher for math policy-makers to know...

PS. Wolframtech:

Ideal for Implementation or coding or other STEM

Wolfram Language



Programminglanguage Supersetcomputation representation Human technical communication anguage

Notebooks(like this)

We're already doing

maths with computers

You need to know how the computer works first

Today's maths helps with real-world computation

Today's maths trains your mind

We're already doing a new computer science subject

Objections

It's too risky to Hand-calculating make this change teaches understanding

You need evidence before you make this change

Get the Children have too basics first much screen time Computers dumb maths down

New ComputationalCurriculum Politics of Delivery

Avoid politicians'logic...

My dog has 4 legs. My cat has 4 legs. Thereforemy dog is cat.



Our mathshas computers. Computer-basedmathshas computers. Therefore, our mathsis computer-basedmaths... Don't confuse major effects of AI: What we need to learn [Subject] How we optimise learning it [Pedagogy]

ie. AI drives need for change, also provides tools

New ComputationalCurriculum Achieve what?

Fixing motivation

Use abstraction to help... ...not scare students off trying.

(Solve real-life, messy, hard, problems. IN ALL SUBJECTS!)

Reorder for conceptual not computational complexity

Eg. 3D geometryfirst Machine-Learningfor Elementary Calculusfor 10-year-olds Reset curricula for human-computer optimisation..

What's for the human? What's for the computer?

CT can be a beachhead across all subjects.

Achieve:

First rate human problem solvers, not third-rate human computers

ie. working a level up from the machines, not competing with what they do best...

Optimisinghuman-computer hybrid decision-making Achieve:

Better enfranchisement across society

Avoiding"Computational"divide Achieving"ComputationalKnowledgeEconomy" Needs Revolution not just Evolution (80% not 10% problem) Compare:

Mass Literacy (From 1800s) Mass ComputationalLiteracy (2020s) Early Countries Leapfrogothers

Enter a New Era of ComputationalEnfranchisement



conradwolfram.com mathsfix.org