UTER SCIENCE & ENGINEERING UNIVERSITY OF MICHIGAN



Mark Guzdial



THE TWO CUITURES AND THE scientific revolution

1959

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Today's Story

- Computing was created to be taught to everyone.
- Are we reaching everyone now? (Hint: "No.")
- - For History: DV4L
 - For Mathematics/Engineering: Pixel Equations
 - For Mathematics/Combinatorics: Counting Sheet
- Big question: What are students learning?



Teaspoon languages as a way to change computing to reach everyone.



and the world of the future MARTIN GREENBERGER

amuses more harmlessly than computation, and nothing is oftener applicable to real business or speculative inquiries. A thousand stories which the gnorant tell, and believe, die away at once when the computist takes them in his grip.

SAMUEL JOHNSON

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Speaker	SIR CHAR Author London, I
Discussants	ELTING E Professor Massachu Norbert Institute I Massachu
Moderator	Howard Dean and Massachus







RLES PERCY SNOW

England

. MORISON of Industrial History setts Institute of Technology WIENER Professor, Emeritus setts Institute of Technology

W. JOHNSON Professor of Industrial Management setts Institute of Technology



"A handful of people, having no relation to the will of society, having no communication with the rest of society, will be taking decisions in secret which are going to affect our lives in the deepest sense."





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- SAMUEL JOHNSON

152.45

Speaker	ALAN J. PERLIS Director of the Computation Center Carnegie Institute of Technology
Discussants	PETER ELIAS Head, Department of Electrical Engine Professor of Electrical Engineering Massachusetts Institute of Technology J. C. R. LICKLIDER Vice President Bolt Beranek & Newman Inc.
Moderator	DONALD G. MARQUIS Professor of Industrial Management Massachusetts Institute of Technology

Programming changes how we understand



1961

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Alan Perlis

Photo: CMU



First published definition of Computer Science

"The study of computers and all the phenomena surrounding them." *Science*, 1967

This is broader than how most people define computer science today. Let's call this Computing









Alan Perlis





Herb Simon

Alan Newell



Percentage of US high school students enrolled in a CS course





By Gender







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Computer science in high schools is growing very slowly

- In England (from Roehampton Report 2018):
 - 53% of schools offer CS GCSE, 12% of students take it.
 - < 20% female
 - 36% offer A Level CS, under 3% take it.
 - < 10% female



Data from Peter Kemp



Fig. 2. GCSE computer science and ICT: influence of IDACI on uptake by gender.



BOTTOMLINE:

THE MAJORITY OF SECONDARY SCHOOL **STUDENTS IN THE US AND ENGLAND HAVE NEVER SEEN COMPUTER SCIENCE**



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AP US History vs. AP CS Principles

399K vs 114K

>50% female vs. <30% female

6x more Black

14x more Hispanic

Teaspoon Languages

 A Teaspoon language is a task-specific programming (TSP) language — specification of process to be executed by a computational agent.

Adding a teaspoon of computing to other subjects.

- CS teacher wants to achieve.
- **USABLE**: Can be learned in less than 10 minutes



USEFUL: Supports a task (learning activity) that an other-than-



#1: DV4L: Data Visualization for Learning

For History Courses



Collaboration with Tammy Shreiner

History In Data Data HELP Enter Driving Question Understand Unde	Graphs
Graph 1: Database (y-axis): Year Range (x-axis): 1800 Craph type: bar Color: SUBMIT Database (y-axis): Populations Location: Rwanda Year Range (x-axis): 1800 Cottor: Rwanda Year Range (x-axis): 1800 1800 1800 1800 1800 1800 1800 1800 1800 1800 1800 1800 1800 1800 1800 1800 1800 1800 1800 1800 1800 1800 1800 1800 1800 1800 1800 1800 1800 1800 1800 1800 1800 1800 1800 1800 1800 1800 1800 1800 1800 1800 1800 1800 1800 1800 1800 1800 1800 1800 1800 1800 1800 1800 1800 1800 1800 1800 1800 1800	1400000 1200000 1200000 1000000 8000000 6000000 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 <td< td=""></td<>





History In Data Visualizations



Graphs

Are there any noticeable differences in the trend of population growth in the following countries? Why?



#2: Pixel Equations For Math and Engineering classes

x > 200 255 y < 200	
y < 200	A
	2 * green
blue > 200	
x = y - 20	Ο

Result Picture Appears Here:

Show Result

300 400 500 500 500 700 800 900 10





Pixel Equations

Select your preferred language

English Idioma/Language

Step 1: Pick your input picture Which picture would you like to use?

File named: arch.jpg



File named: Bayamon.jpeg



File named: beach.jpg



File named: dog.png



File named: san-juan.jpeg



File named: TSM-Map.png



File named: detroit.jpg



File named: DetroitSkyline.jpg









*

which will select all pixels where the x coordinate is greater than the y coordinate.

Then write equations for how to change red, green, and blue (rojo, verde, y azul) for the selected pixels. You can invert each color by subtracting from 255 (e.g., set red/rojo to 255-red (0 255-rojo)).

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Result Picture Appears Here:

Show Result



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set rea/rojo to 255-rea (0 255-rojo)).

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x > 200	255
y < 200	
•	
	10
	1

Result Picture Appears Here:

Show Result

0 100 200 300 400 500 600 700 800 800 900 10000 10000 11000 12000



200 400 500

Red Set Green Set Blue nar Rojo Asignar Verde Asignar Azul



men write equations for now to change red, green, and blue (rojo, verde, y azur) for the selected pixels. You can invert each color by subtracting from 255 (e.g., set red/rojo to 255-red (o 255-rojo)).

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Result Picture Appears Here:

Show Result



Set Green Set Blue ?ed nar Rojo Asignar Verde Asignar Azul



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#3: Counting Sheets Elise Lockwood: Teaching combinatorics with Python

Student challenge: How many arrangements do you expect to get from the letters in the word **ROCKET?**

- No repeated letters
- Order matters

Why do you think that? How will the list of outcomes be structured?





```
arrangements = 0
People = ['R', 'O', 'C', 'K', 'E', 'T']
for p1 in People:
    for p2 in People:
        if p2 != p1:
            for p3 in People:
                if p3 != p1 and p3 != p2:
                    for p4 in People:
                        if p4 != p3 and p4 != p2 and p4 != p1:
                             for p5 in People:
                                 if p5!=p4 and p5!=p3 and p5!=p2 and p5!=p1:
                                     for p6 in People:
                                         if p6!=p5 and p6!=p4 and p6!=p3 and p6!=p2 and p6!=p1:
                                             arrangements = arrangements + 1
                                             print(p1, p2, p3, p4, p5, p6)
print(arrangements)
```

"Reinforcing key combinatorial ideas in a computational setting: A case of encoding outcomes in computer programming," 2021, Journal of Mathematical Behavior, Lockwood and De Chenne







Counting Sheet Interactive Tool

First time here?

2: Shirts and pants	~	
Counting Sheet: 0		
col1	col2	col3
tee,polo,swea ter	jeans,khaki	
Generate Chart O Results: ①	utput O	
tee jeans		
polo jeans		
polo khaki		

sweater jeans

sweater khaki

Collaboration with Elise Lockwood









WHAT ARE STUDENTS **LEARNING HERE?**

Is this computing education?

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Rich, Strickland, Binkowski, Moran, and Franklin (ICER 2017) asked the question:

What's the starting place for K-8 CS learners?







Figure 3: Sequence learning trajectory.

Figure 4: Repetition learning trajectory.



Proposed: What comes first when learning programming?

- 1. Precision and completeness are important when writing instructions in advance.
- 2. Different sets of instructions can produce the same outcome.
- 3. Programs are made by assembling instructions from a limited set.
- 4. Some tasks involve repeating actions.
- 5. Programs use conditions to end loops.







Figure 3: Sequence learning trajectory.



Figure 4: Repetition learning trajectory.





Scratch fluency doesn't need that whole list

- Over 60 million users.
- Most Scratch projects are stories that use...
 - Only Forever loops
 - No booleans
 - Just movement and sequence.

There is *expressive* power in even a subset of CS.





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Bootstrap: Algebra doesn't use all of that list

- Improves learning in algebra
- Students do not code repetition.

Functional

Unit	Game Feature	Programming Concept	Math Concept
1	locating elements on screen	expressions, Circles of Evaluation	coordinates
2	creating text and images	string and image operations	domain, range, kinds of data
3–5	making moving images	defining functions, examples	multiple function representations: as formulas and as tables
6	determine when game elements are off-screen	Booleans and Boolean operators	inequalities
7	responding to key-presses	conditional	piecewise function
8	collision detection	(nothing new)	Pythagorean Theorem
9	polishing games for presentation	code reviews	explaining math concepts to others

Figure 1: Curriculum structure: each unit introduces game, programming, and math concepts in parallel.







There is *learning* power in even a subset of CS.

Schanzer, Fisler, Krishnamurthi, Felleisen, 2015





Learning challenges that our teachers face

- Intermediate representations:
 - program execution).
- **Debugging**:
 - your intention. the result, you will have to debug.





And probably our students, too.

Much of computing involves use of a notation (HTML, programs) that is interpreted by a computer for a final result (web page,

The computer only interprets your notation — it does not know

When the interpretation does not match what you intended for





REPEATING THE BOTTOMLINE:

THE MAJORITY OF SECONDARY SCHOOL **STUDENTS IN THE US AND ENGLAND HAVE NEVER** SEEN COMPUTER SCIENCE

We don't know much about teaching <u>all</u> students about computing



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This too is Programming

A place to learn about intermediate representations and debugging. Useful tools in social studies, mathematics, and engineering.

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2/3 of the world does not speak English.

Reaching everyone requires new languages and tools



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blue > 250			20
verde > 120		80	

Step 3: Run Equations

Result Picture Appears Here:









Teaspoon Languages as a CS for All Strategy

- Hour of Code: One hour of a Turing-complete programming language every year.
- Teaspoon Languages: One to three little languages in every social studies, mathematics, and language arts class.
- Which results in more retained and transferrable CS learning? Which creates more of a school culture about using programming across disciplines?







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Time to Play with **PROTOTYPES**

For history: DV4L



Graph 2:

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For Mathematics/Engineering: **Pixel Equations**

For Mathematics/Counting: **Counting Sheets**





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Questions to Think About

- What would it take to get other-than-CS teachers in your schools to try a Teaspoon language?
- Do you see students struggling with the fundamental issues of intermediate representations and the left side of the learning trajectories?
- How would you improve Teaspoon languages? For what tasks should we be developing new Teaspoon languages?















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Counting sheet: 0	12	<i>a</i> .
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	slot1	
Generate Chart	Output 0	
Results: You can	select the results and copy them into 1	he Analysis Tool
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Collaborators on This Work

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Thank you!



SPARE SLIDES



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