2024 CRA CONFERENCE

Visions for the Future of Computing Education

Moderator:

Ran Libeskind-Hadas
Claremont McKenna College

Visions for the Future of Computing Education

Panelists:

Adrienne Decker
University at Buffalo

Mark Weiss
Florida International University

Alfred Spector
Massachusetts Institute of Technology

Leo Porter
University of California San Diego

Diana Franklin
University of Chicago

A Vision for the Next 15 Years of Computing Education

Adrienne Decker (University at Buffalo) and Mark Weiss (Florida International University)
adrienne@buffalo.edu weiss@fiu.edu

Read the final report
Podcasts
Other workshop documents

https://bit.ly/cerFutureFinalReport

This material is based upon work supported by the National Science Foundation under Grant No. 2039833 and 2039848. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

Piecing Together the Next 15 Years…

Lack of Evolution in the Curriculum

What needs to change

- *Ethics, Multiple Perspectives, Equity, Social Justice, Humanities*

Beyond Changing the Curriculum

- *Pedagogy, Retention Efforts, Hidden Curriculum, Informal Education, Computing is a Fundamental Literacy*

Questions

Which of these ideas are you or your departments currently looking at?

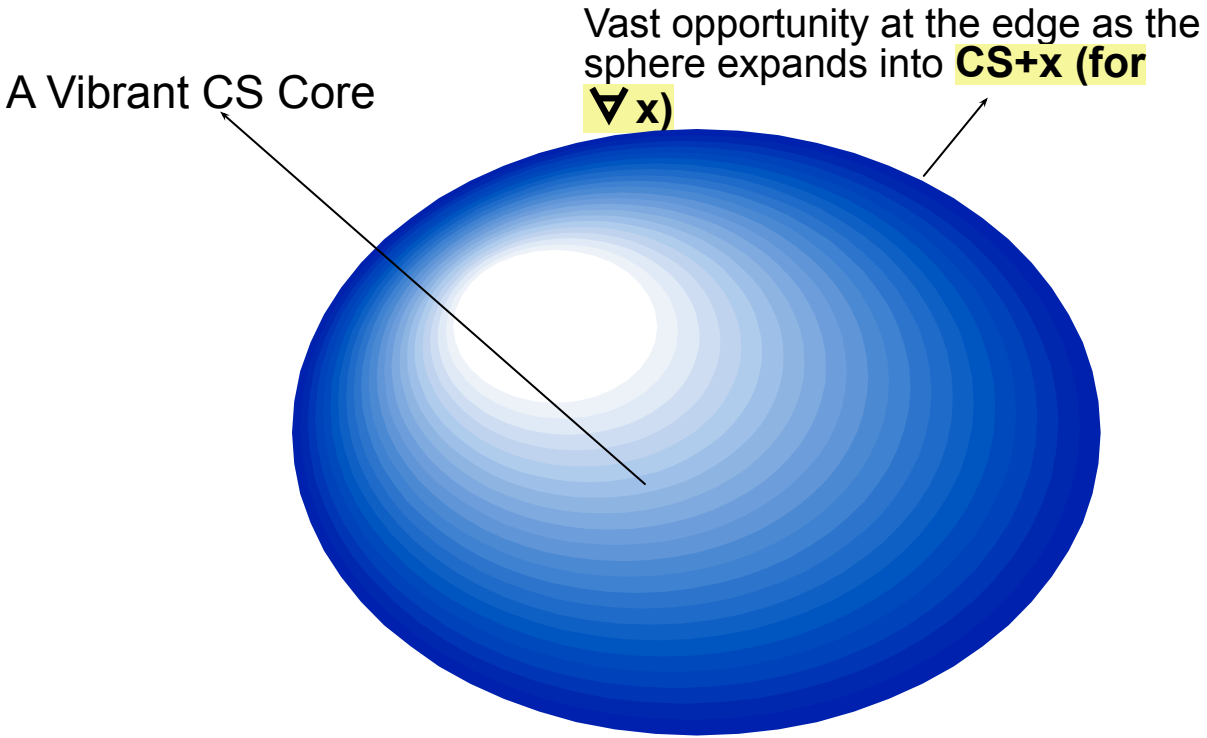
What things might you want to bring to your department for future considerations?

Broadening Education in AI & Data Science

{CS, AI, DS}  Liberal Arts

Alfred Z. Spector
Visiting Scholar, MIT
alfreds@mit.edu

CS: The Expanding Sphere (from 2004)



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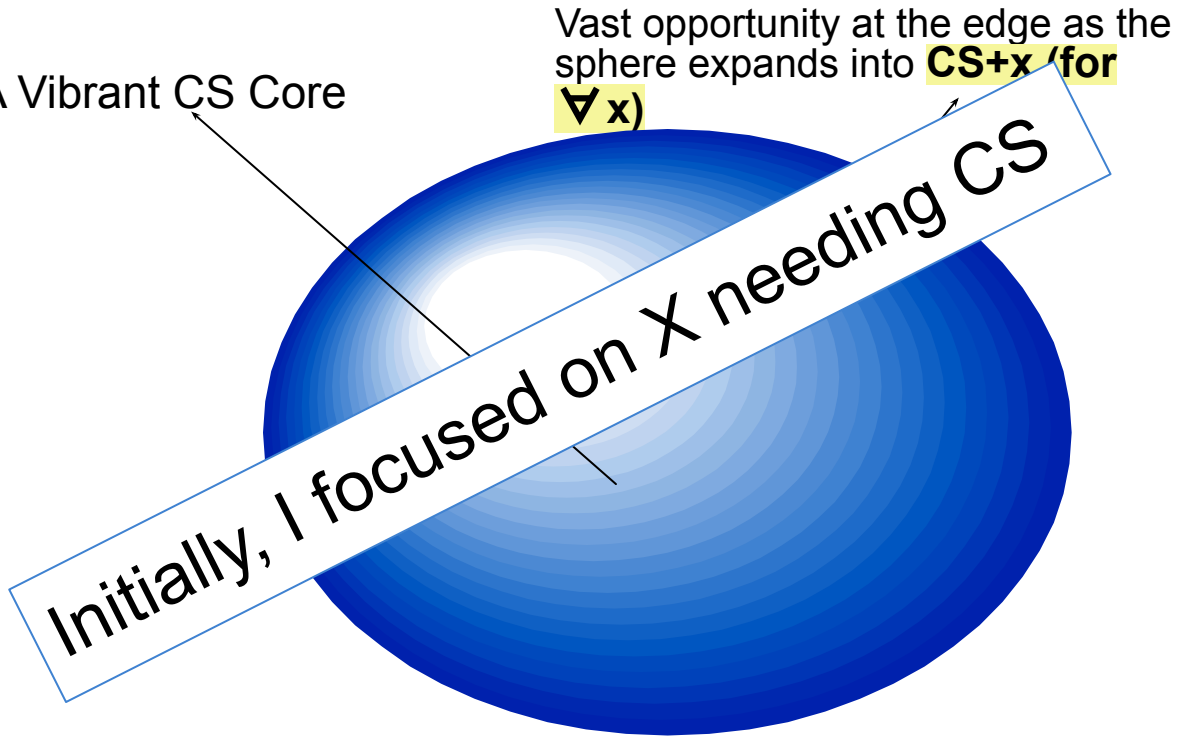

Expanding Sphere of Computer Science

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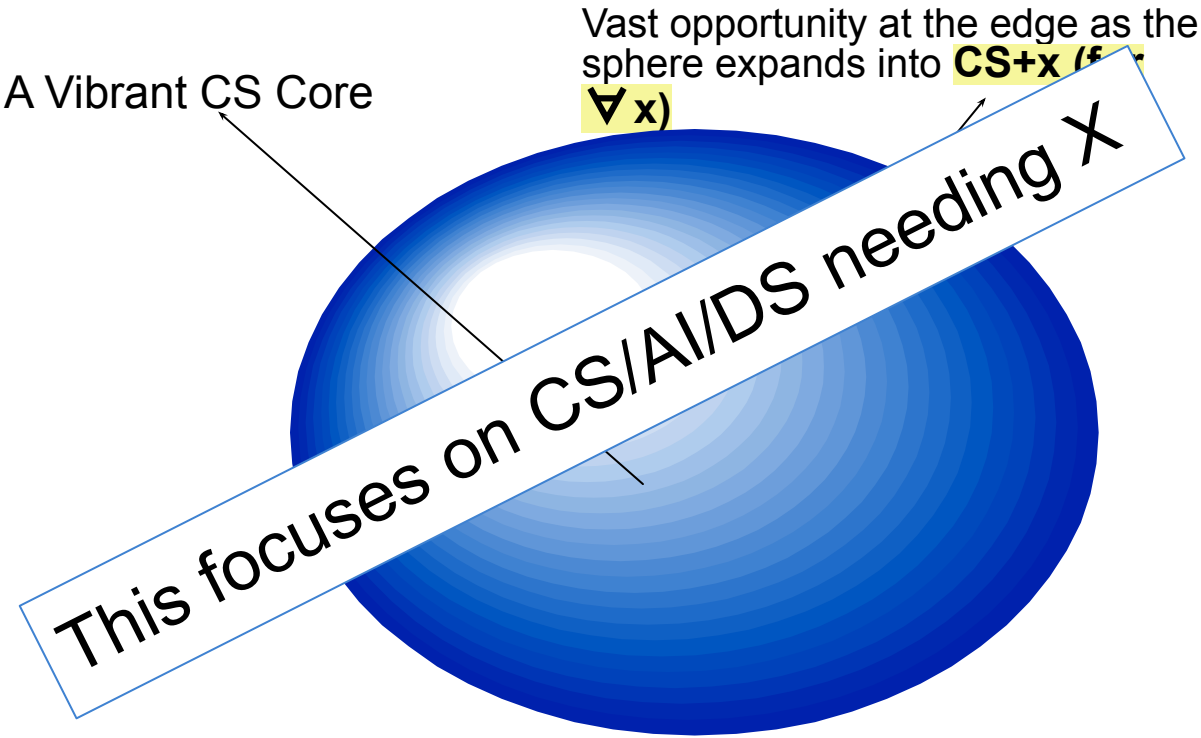


Expanding Sphere of Computer Science

Diversity of Applications Leads to Complex Challenges

- We are addressing problems that have never been solved: so called, “WICKED PROBLEMS”
- Solutions are challenging in almost all dimensions

So, This requires focus on a broader set of:
Technical Challenges and Complex Tradeoffs

Proposal to Achieve Good Results: 3-Part Framework[1]

1. Technical Contributors: The Rubric

2. Integrity

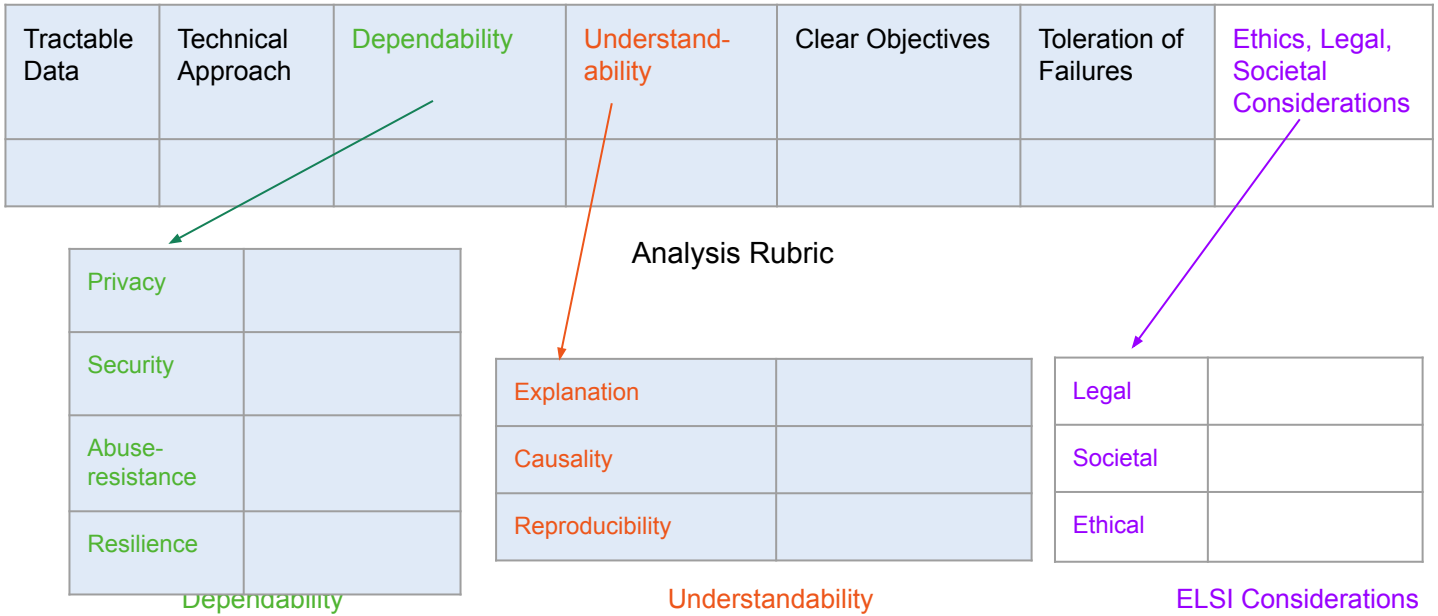
3. The Liberal Arts:
 - Ethical Frameworks, sure
 - But other disciplines are as important.

A Good Outcome

[1]Gaining Benefit from Computing and Data Science
Why ethics is not enough
Communications of the ACM, Feb. 2024.

Part 1. Technical Contributors (Analysis Rubric)

- Elements, for example, specific to engineering and science fields
  - Structural engineering: corrosion, hairline fractures, etc.
  - Medicine: side effects, dosing, cost-benefit, etc, etc.
- For data science and AI: most rubric elements:
- Blue shaded is clear responsibility of technical faculty



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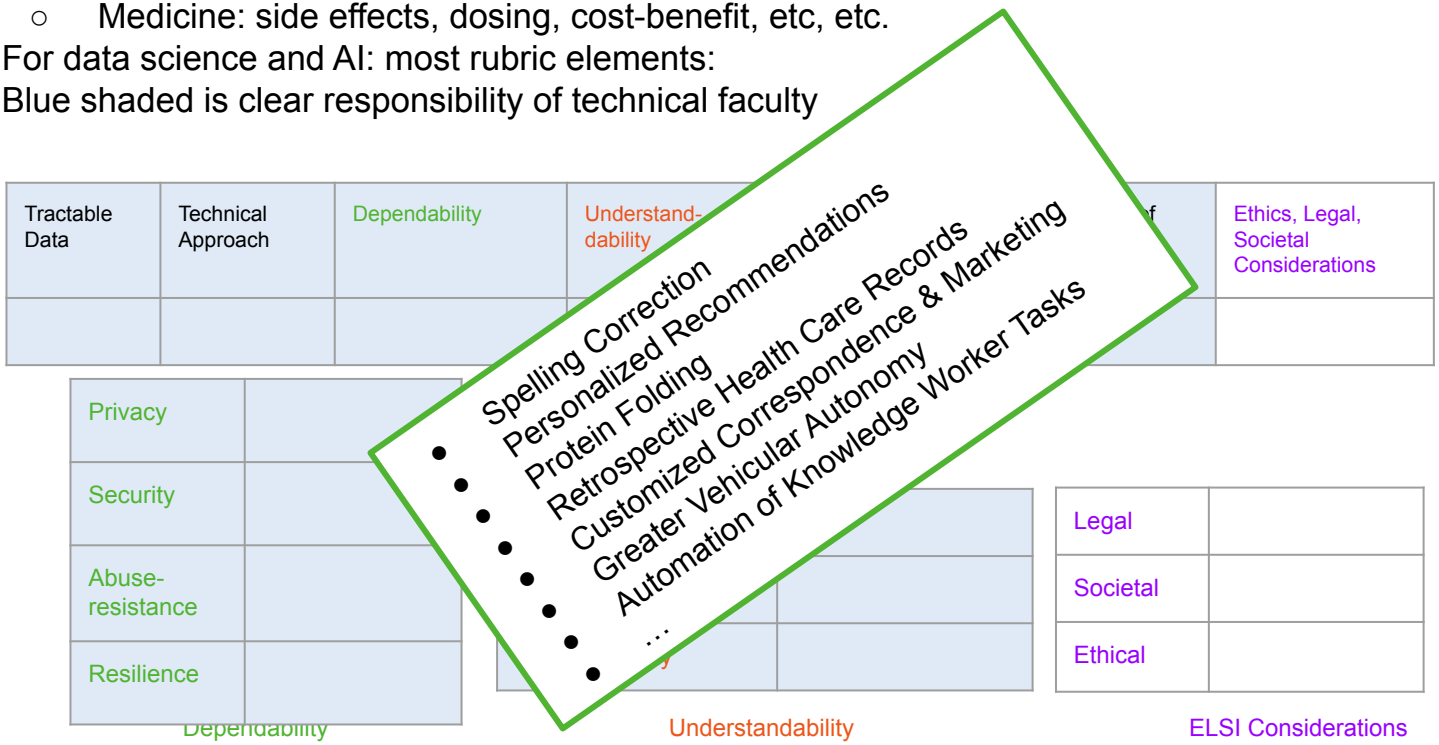
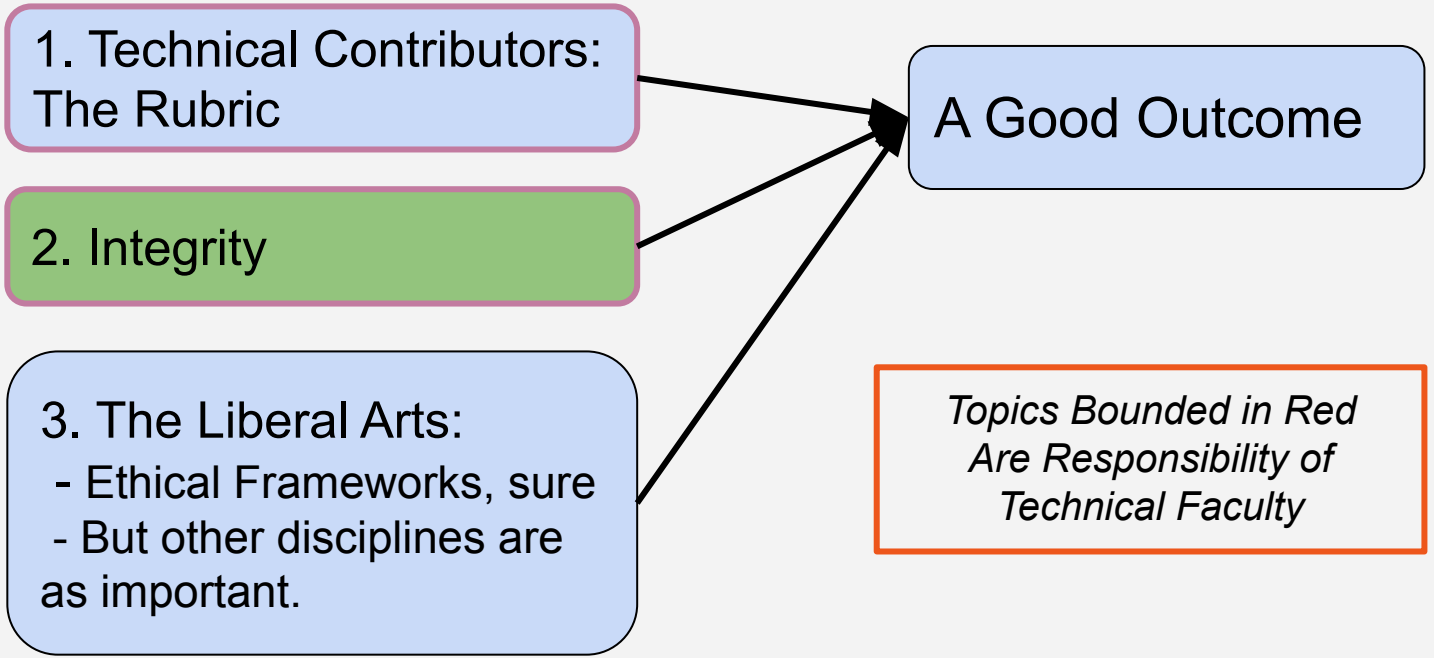


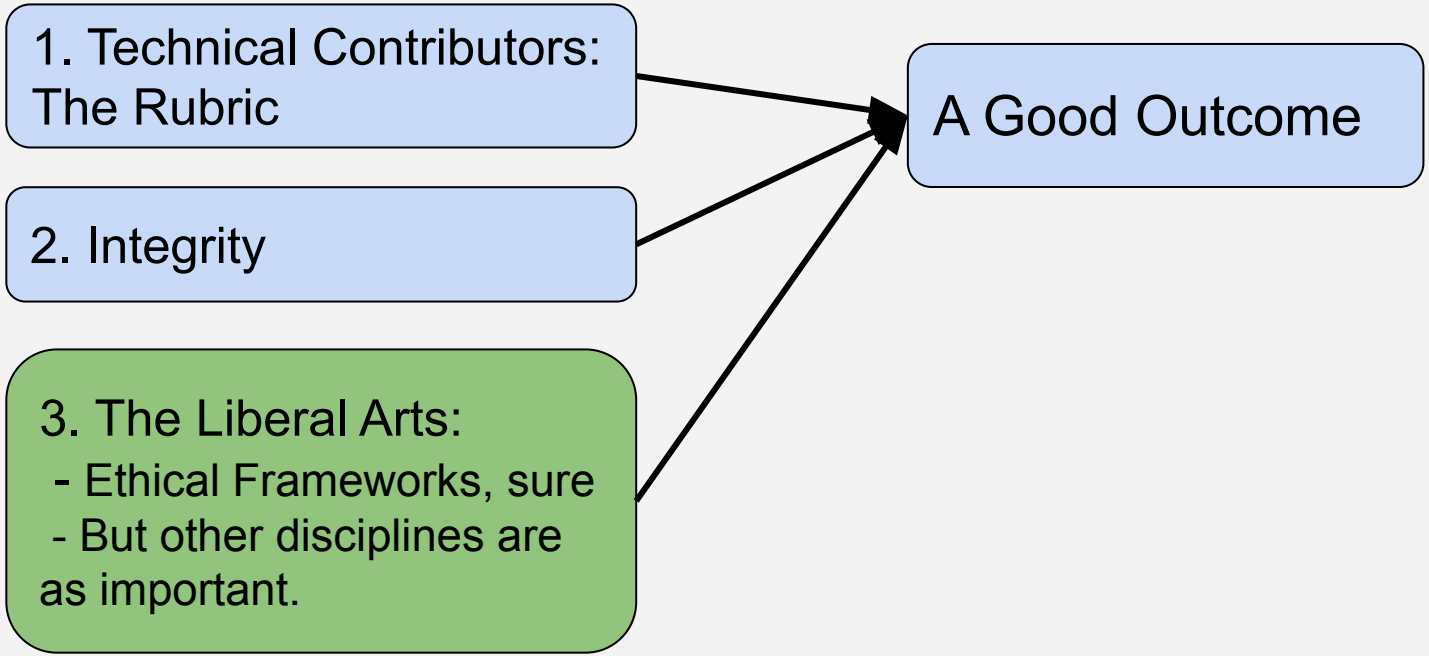
Achieving Good Results: 3-Part Framework



Part 2. Integrity

- We must be Honest, Accountable, Accurate, Informed, Forthcoming, Objective, Rigorous, Respectful, Lawful
- Why call out **Integrity** specifically?
  - Many societies, organizations, professions seemingly less focused on it.
    Yet, Integrity is the foundation of trust, reproducibility, and reasoning.
  - It's an increasingly important topic: E.g., DataColada, cherry-picking, p-hacking, etc.
  - We can and should be individually responsible in all our organizations, classes, etc.
  - It is clearer than other topics in ethics.
- This applies to our research, communication, education, etc.

Achieving Good Results: 3-Part Framework



Part 3. Frameworks for Tradeoffs & Making Decisions

A. **Ethical Frameworks (The World We Want) →**
- **Idealism**
- **The world we want**
  - **Belmont Principles** (from Human Subject Research, 1978)
  - **Jus ad Bellum** and **Jus in Bello**
  - *And much more*

***But,* Ethics is Not Enough**

B. **Broader Considerations (Perhaps, Pragmatism, The World We Can Achieve) →**
- **Economics**
- **Political Science**
- **History**
- **Literature**
- ***And others***
- ***… Broadly, the Liberal Arts***

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This is broadly The Liberal Arts and we need help from our colleagues

CS/AI/DS Faculty

Teach the exciting subjects, for sure

Also, teach other rubric elements

Emphasize Integrity

University-Wide

Impose distribution structure on student liberal arts requirements

If necessary, work w/colleagues in Humanities and Social Sciences to have needed courses

Recap - A Structure for Applying DS and AI

- Our fields are very powerful.
- The **Three-Part Framework** helps us understand the trade-offs that we must make
  - Technical care
  - Integrity
  - Breadth of education/perspective
- CS/AI/DS faculty our work to do on Parts 1 and 2
- Part 3 requires us to leverage the broader university

www.datascienceincontext.com
Or your favorite bookseller

Data Science and AI in Context: Summary and Insights - HDSR July 2024

Three Part Framework 2024 - CACM

Question

- What do you think about influencing your students to take certain breadth courses that of CS/AI/DS?

Computing Education in the Era of GenAI

Leo Porter (UC San Diego)

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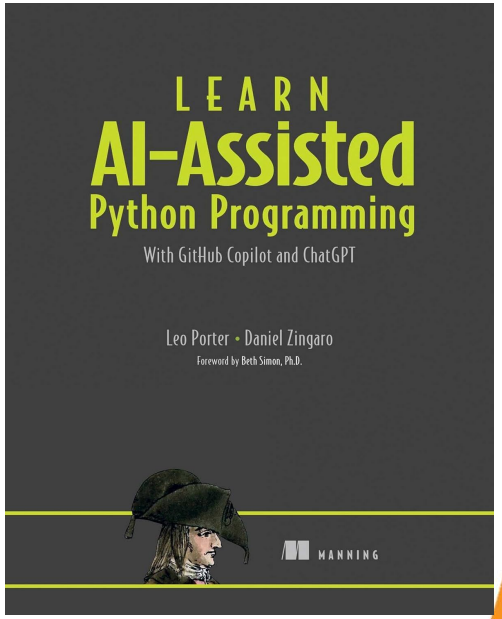


My involvement:

- Building materials for educators to incorporate GenAI, including authoring a textbook for learning to program
  - Email: leporter@ucsd.edu for a copy
- Building and studying CS1 courses that incorporate GenAI
  - Experience Report: https://bit.ly/CS1-LLMs
- Studying student perceptions of GenAI as a tutor/TA

GenAI can solve assessments

- LLMs solves CS1 assignments [1]
  - Copilot solved 47.6% of problems on its first attempt and that went up to 79.5% after prompt engineering
- LLMs solve CS1 exams [2]
  - In 2021, Codex got 78.5% on Exam 1 and 78% on Exam 2
  - In 2023, GPT-4 got 99.5% on Exam 1 and 94.4% on Exam 2

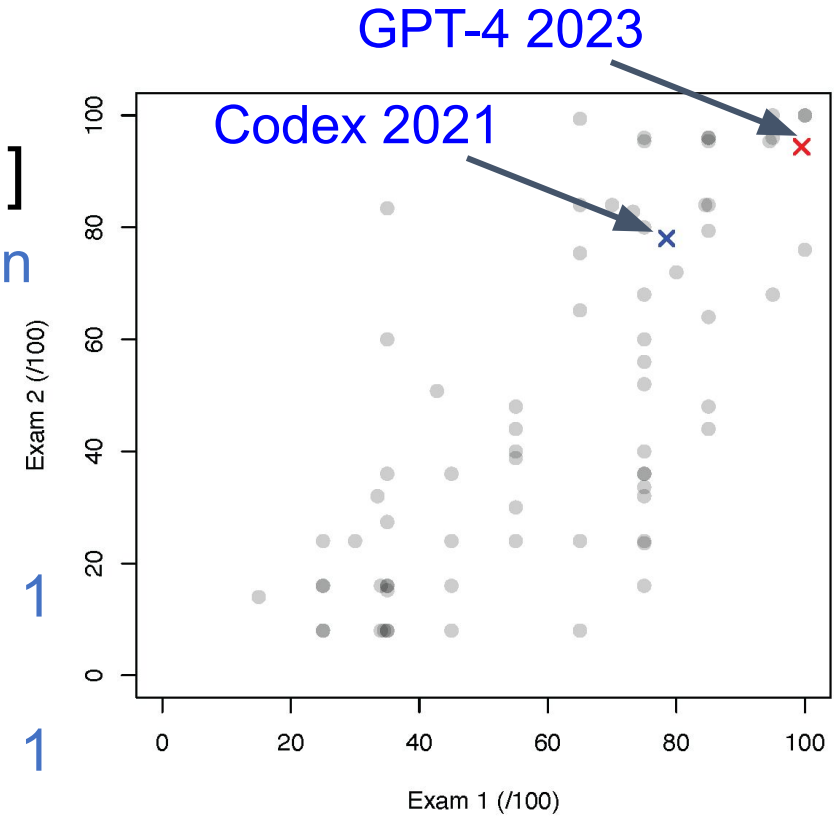


Figure from [2]. Student performance on CS1 exams. Blue is Codex, Red is GPT-4

1. Denny et al. Conversing with Copilot: Exploring Prompt Engineering for Solving CS1 Problems Using Natural Language. ACM SIGCSE 2023.
2. Denny et al. Computing Education in the Era of Generative AI. CACM 2024.

GenAI can be an effective Tutor

Tools include: CodeHelp [1], CodeAid [2], etc.

- Often include guardrails to limit responses

Students value these tools [3]

- Lack of judgement
- Ease of access
- Focus on learning

Comparison with Human Tutors

- Human tutors often give away answers and pass judgements [4]

1. Denny et al. Conversing with Copilot: Exploring Prompt Engineering for Solving CS1 Problems Using Natural Language. SIGCSE 2023.
2. Kazemitabaar et al. CodeAid: Evaluating a Classroom Deployment of an LLM-based Programming Assistant that Balances Student and Educator Needs. CHI 2024.
3. Denny et al. Computing Education in the Era of Generative AI. CACM 2024.
4. Krause-Levy et al. An exploration of student-tutor interactions in computing. ITiCSE 2022.

GenAI May Change the Skills We Teach

What skills are needed to write software?

- Consider both majors and non-majors

Some skills become more important

- Code Reading
- Testing
- Debugging
- Problem Decomposition

How to change our curriculum in light of GenAI is one of the biggest challenge we face

Questions

1. How is your department changing assessments in light of GenAI?
2. How is your department incorporating GenAI as TAs?
3. How is your department adjusting to the shift in skills needed to write software?

- Please e-mail leporter@ucsd.edu for an educator copy of “Learn AI Assisted Python Programming: With GitHub Copilot and ChatGPT
- Experience report on introductory programming course incorporating LLMs (CS1-LLM) can be found at: https://bit.ly/CS1-LLMs

Quantum Computing Education: What, Why, and How

Diana Franklin

dmfranklin@uchicago.edu

Understanding the motivations and mechanisms for Quantum Computing Education

What is Quantum Computing?

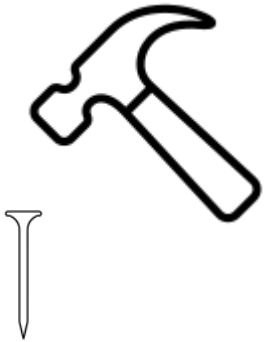
Leveraging the behavior of **individual atoms** to perform computation

Macroeconomics vs microeconomics:

Groups of people (macro) operate differently than individual people (micro)

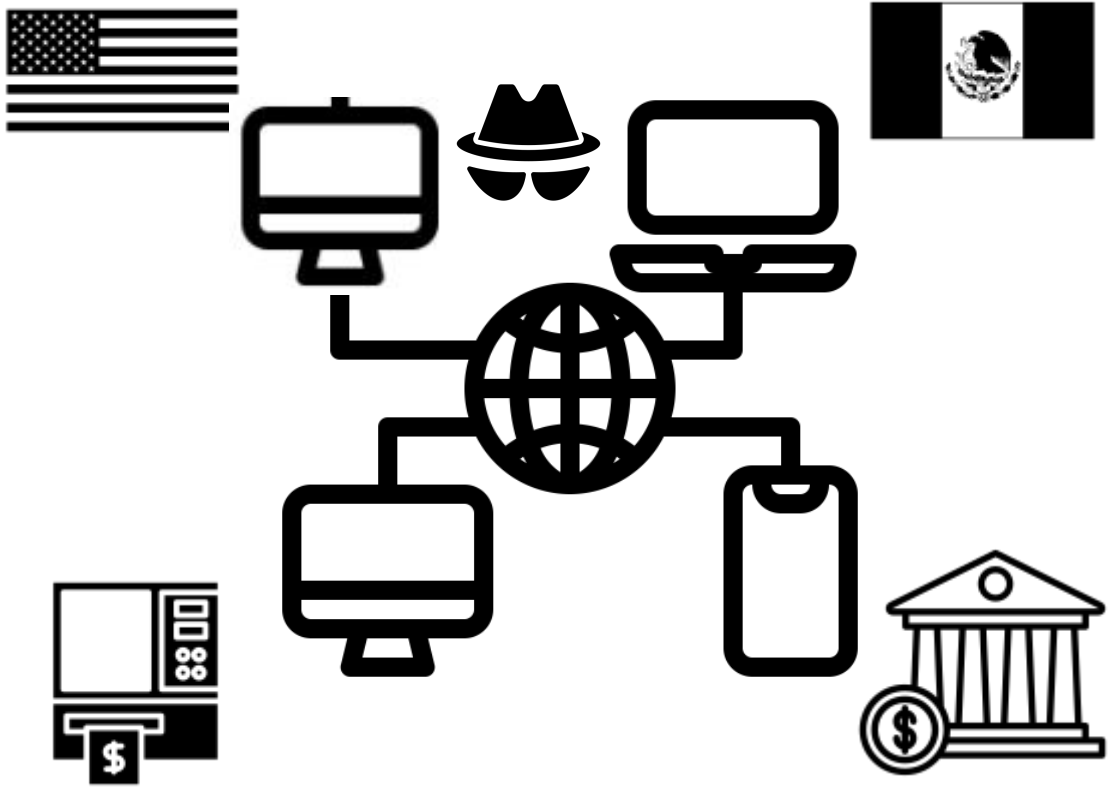
Likewise, groups of atoms / molecules act differently than individual ones.

Quantum Computing:
A hammer looking for a nail



What problems may it solve?

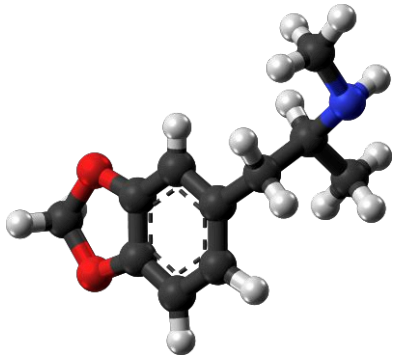
Cryptography



What problems may it solve?

Optimal routing

What problems may it solve?



Molecular simulation

Drug Design

Fertilizer Production

Why QIS-Ed? All populations need to be on the design team - those left out suffer

Airbags killed short people

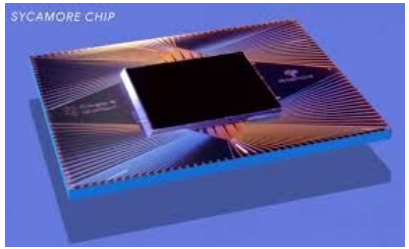
Siri / Alexa didn't understand people with accents

Facial recognition misidentifies dark-skinned people

Machine learning perpetuates historical discrimination

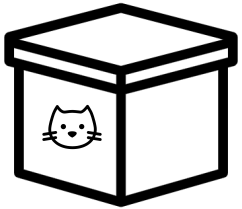
Why now??
Larger computers online, coding opportunities

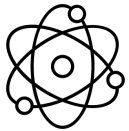
IBM Condor:
1121 qubits

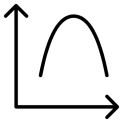


Google
Sycamore:
70 qubits

How do we teach to young audiences?







Identify the ABC's of Quantum

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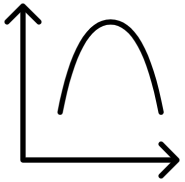
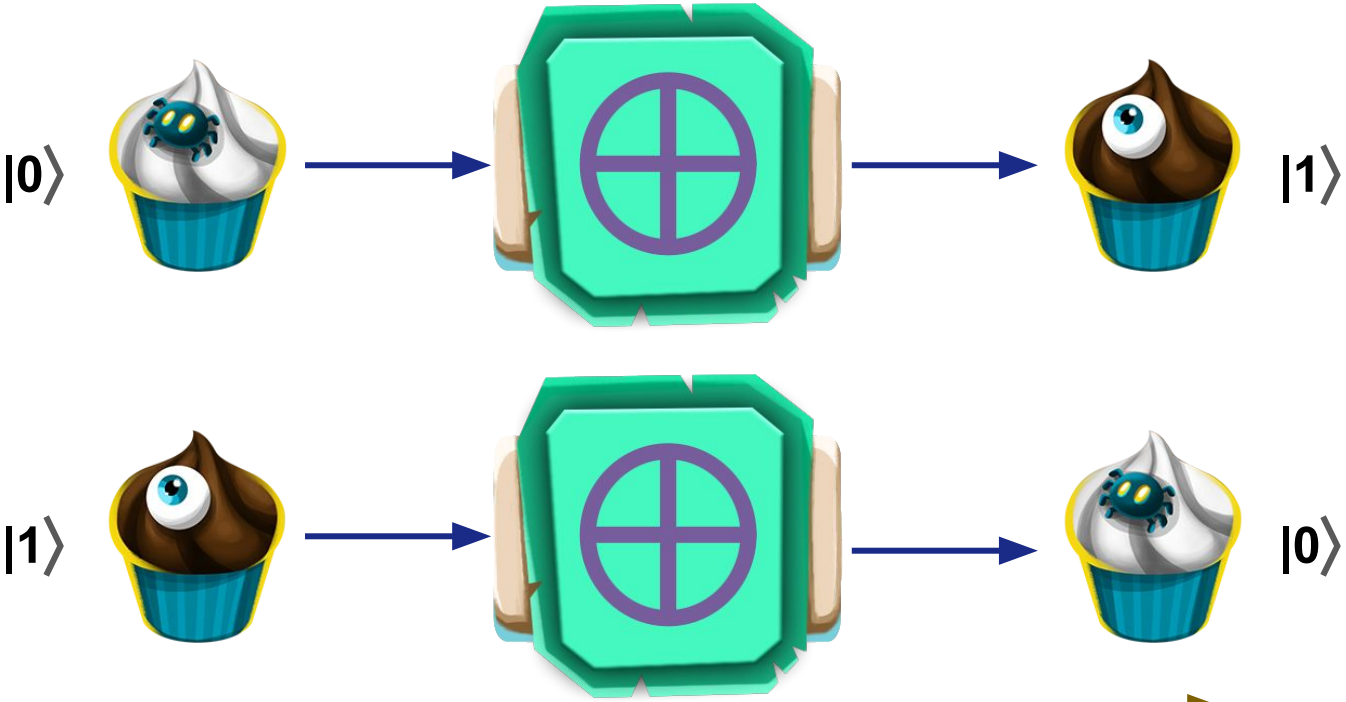
A B C

1 2 3



K-12 QIS Key Concepts, HS Framework, MS Framework - https://q12education.org/

Math Late + FUN: NOT or X gate - flavor flipper 2024 CRA CONFERENCE



Modified from Q is for Quantum, Terry Rudolph

Make it FUN!

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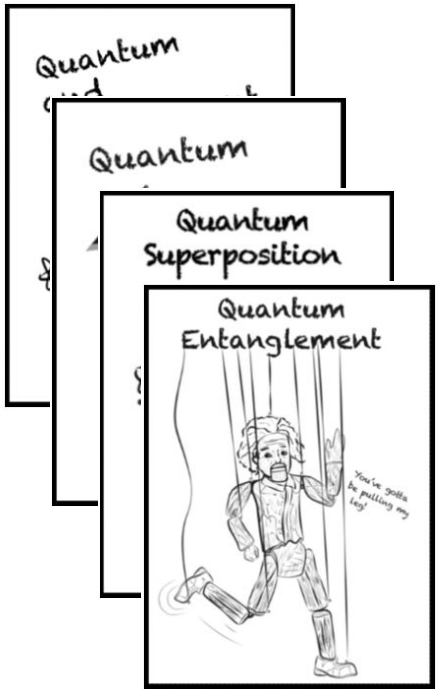
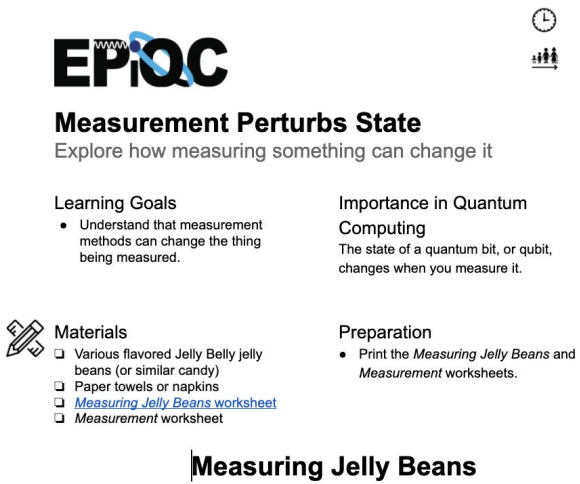
Zines



Activities



EPiQC

Measurement Perturbs State

Explore how measuring something can change it

Learning Goals
- Understand that measurement methods can change the thing being measured.

Importance in Quantum Computing
The state of a quantum bit, or qubit, changes when you measure it.

Materials
- ❑ Various flavored Jelly Belly jelly beans (or similar candy)
- ❑ Paper towels or napkins
- ❑ *Measuring Jelly Beans* worksheet
- ❑ *Measurement* worksheet

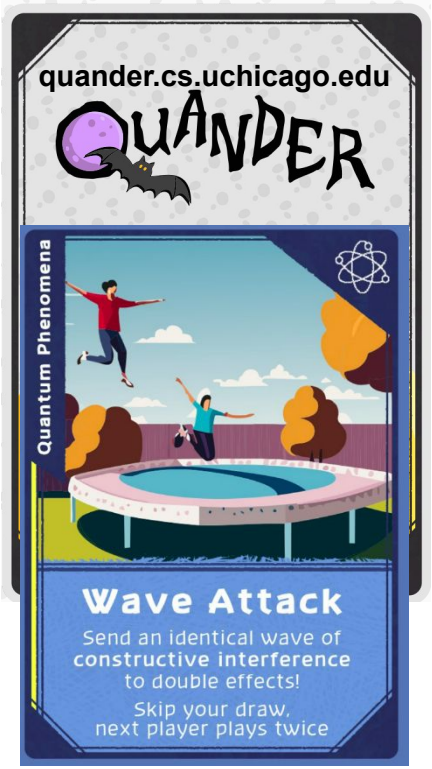
Preparation
- Print the *Measuring Jelly Beans* and *Measurement* worksheets.

Measuring Jelly Beans

I have many to hand out:
Zines & Quander cards

Game night last night:
Collapsing Qubits card game

Games



At the college level - a gentle intro

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Visual representation (black and white balls, not cupcakes)
Math late / no linear algebra pre-reqs
- Teach what you need
- De-emphasize proofs

Focus on the computation
- How do phenomena affect operations?
- What are the useful operation combinations?
- What do the algorithms look like?

Question

What barriers are there to offering a QC elective at your school?

- Interest?
- Expertise?
- Materials?

What barriers are there to incorporating QC into K-12 outreach?

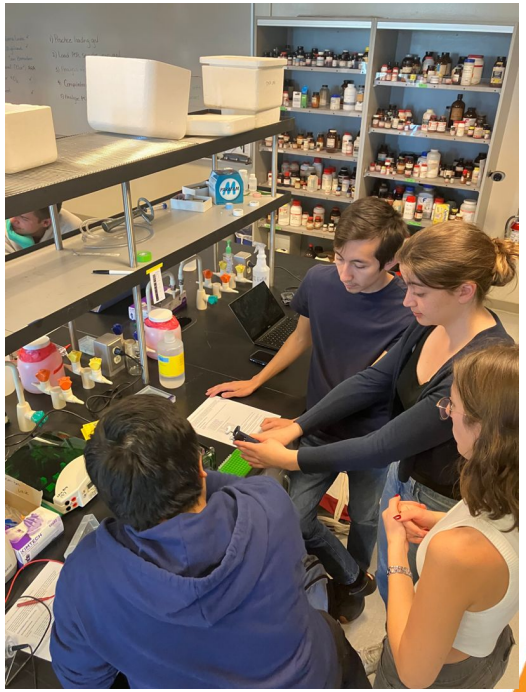
- Interest?
- Expertise?
- Materials?

X + CS: Computing Embedded in a Natural Sciences Curriculum

Ran Libeskind-Hadas

rhadas@cmc.edu

- New undergraduate science program
- Integration on three “dimensions”
- Computing literacy from “day 1”



Question

- What are the opportunities (or barriers) to integrate computing into “general education” courses at your institution?