



# Academia + Industry to **ACCELERATE** Learning

Marti Hearst  
UC Berkeley

BayLan 2018



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BY DEEPP COLVIN

HUMANS ARE UNDERRATED

THE 3 SKILLS YOU NEED TO THRIVE IN THE NEW WORKPLACE

\* CODING ISN'T ONE OF THEM.

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The New York Times Magazine

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Topics

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LEARNING TO LOVE OUR ROBOT CO-WORKERS

The most important frontier for robots is not the work they take from humans but the work they do with humans – which requires learning on both sides.

BY KIM TINGLEY FEB. 23, 2017

Unshackled algorithms

Machine-learning promises to shake up large swathes of finance

In fields from trading to credit assessment to fraud prevention, machine-learning is advancing

THE CHRONICLE OF HIGHER EDUCATION

NEWS OPINION

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Robot-Proof: How Colleges Can Keep People Relevant in the Workplace

By Joseph E. Aoun | JANUARY 27, 2016

ROBOT-PROOF JOBS with David Brancaccio

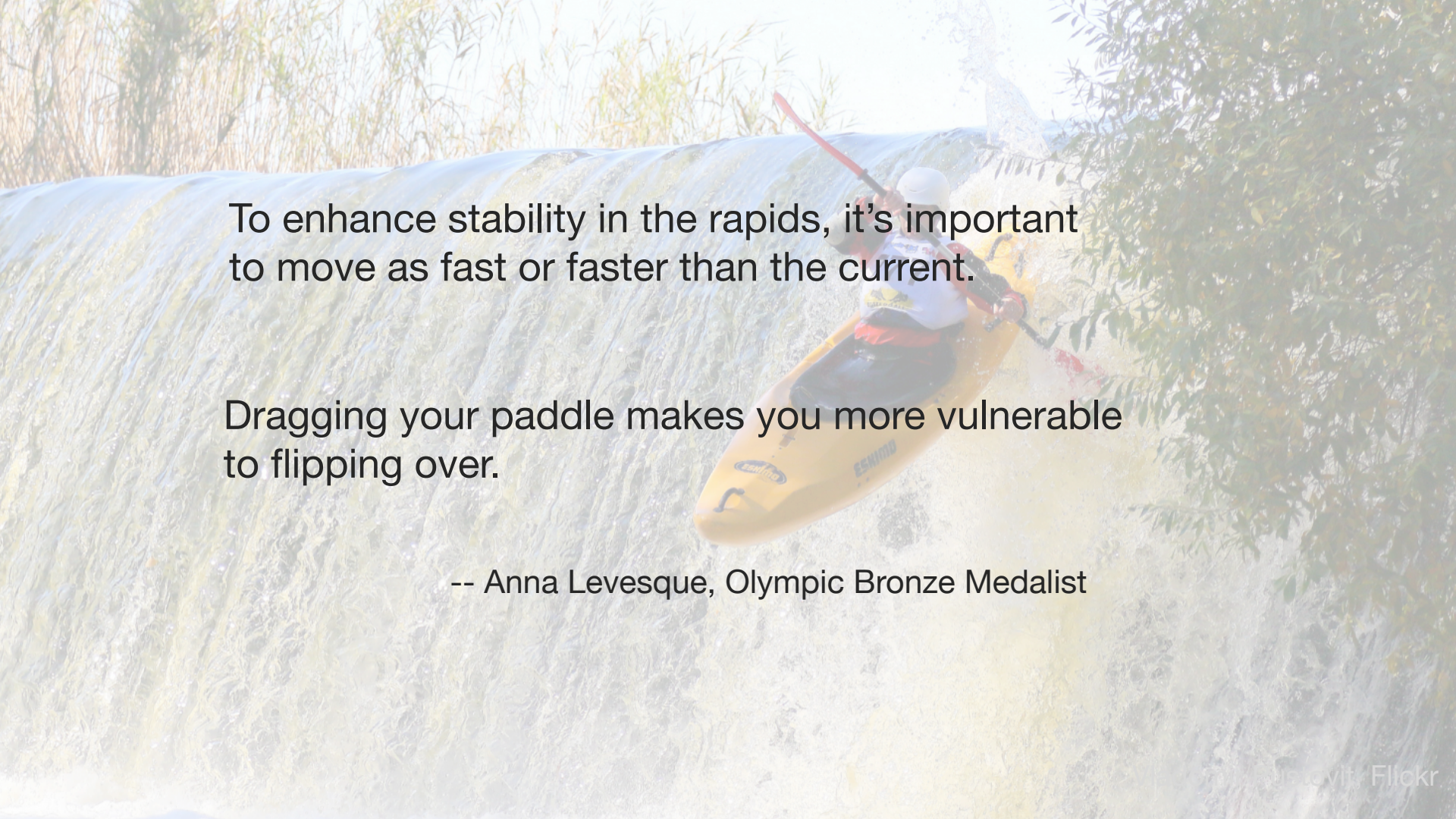
ROBOT-PROOF JOBS

with David Brancaccio







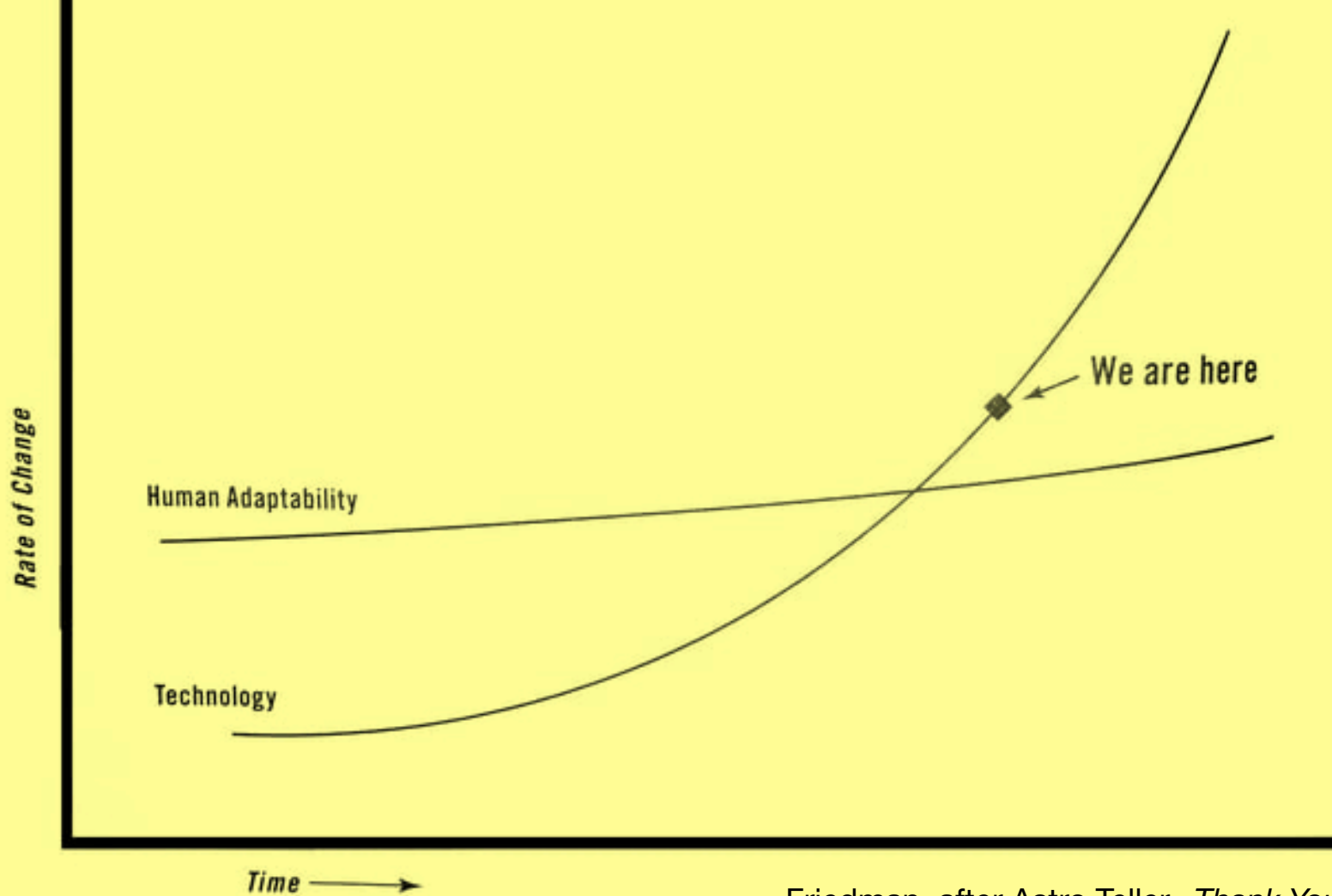
A kayaker in a yellow kayak is shown navigating a turbulent waterfall. The kayaker is wearing a white helmet and a white shirt with a logo. The kayak is yellow with "ESNIDE" written on it. The water is white and foamy, indicating a rapid or waterfall. The background shows some green foliage on the right and some dry grass on the left.

To enhance stability in the rapids, it's important to move as fast or faster than the current.

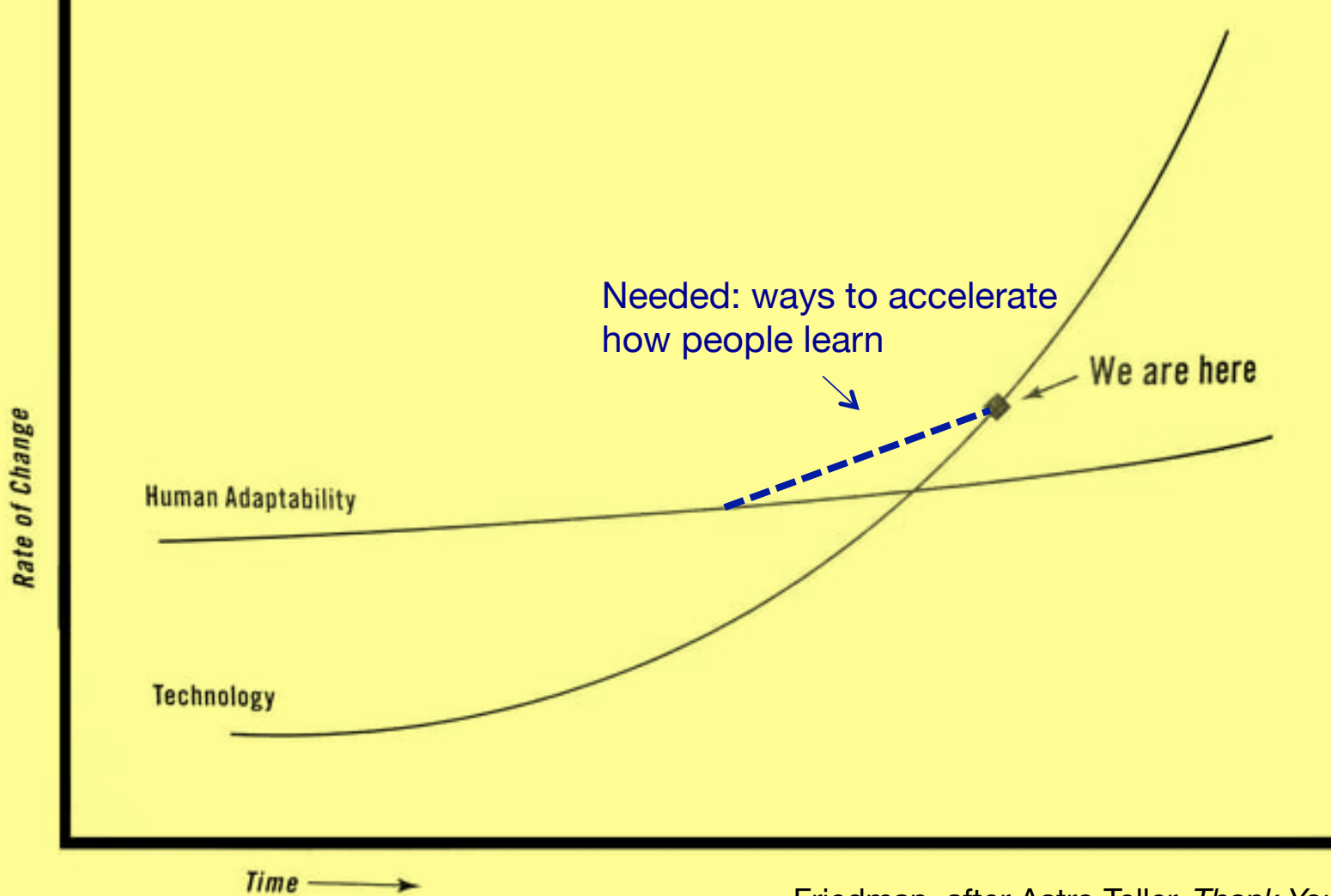
Dragging your paddle makes you more vulnerable to flipping over.

-- Anna Levesque, Olympic Bronze Medalist





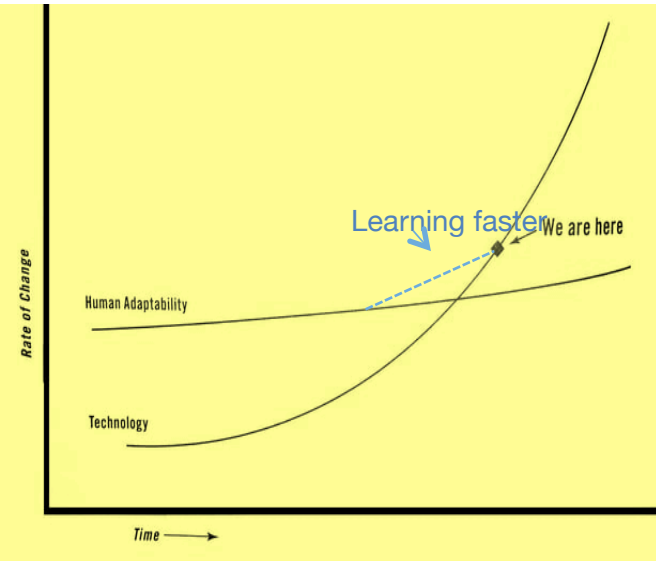








“There is a mismatch between the pace of change and our ability to develop the learning systems ... that would enable citizens to get the most out of these accelerations and cushion their worst impacts.”



We can apply features that drive technological innovation to figure out how to enhance human's adaptability.



# Two Simultaneous Disruptions Related to Technology

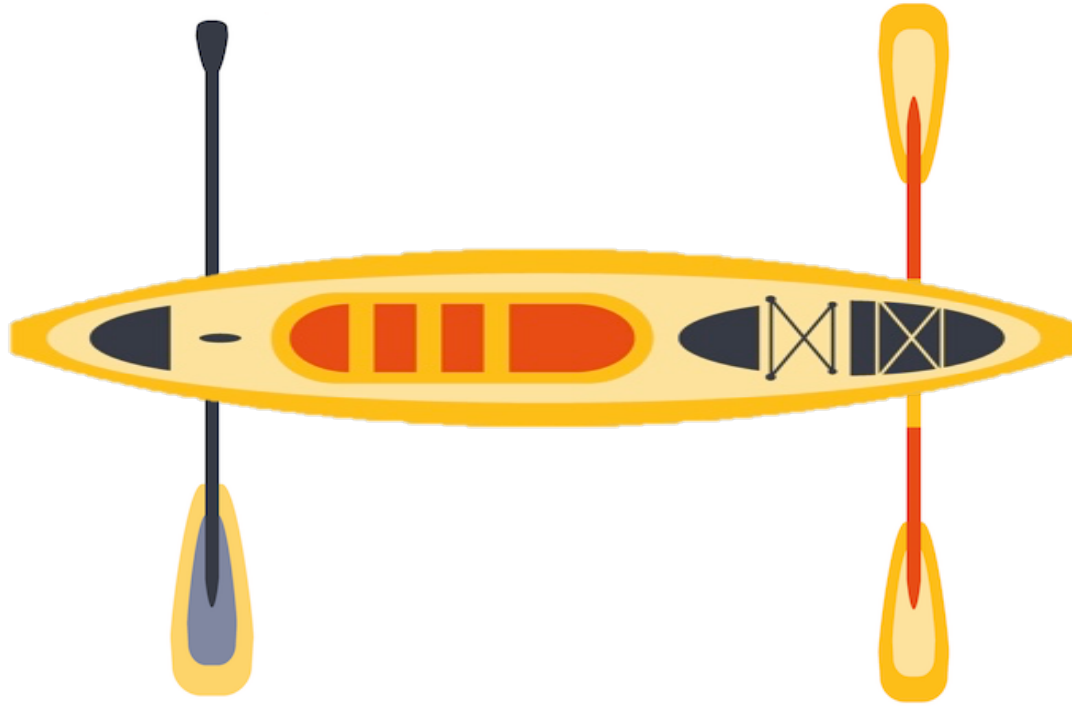


Job Automation



Teaching/Learning Online

# Both Should be Benefitting by the Mitigating Factor of AI



Job Automation

Teaching/Learning Online



# The Challenge

- Although for decades technology has been changing the employment landscape, the change seems to be accelerating today.
- **One way** to address this is to help people help themselves by improving our methods for teaching and learning.
- **One method** for improving our teaching and learning is for AI to play a bigger role than it has to date.
- Can industry + academia working together make a **real breakthrough**?

# EXAMPLE PAIN POINT: AUTOMATING FEEDBACK IN MOOCS



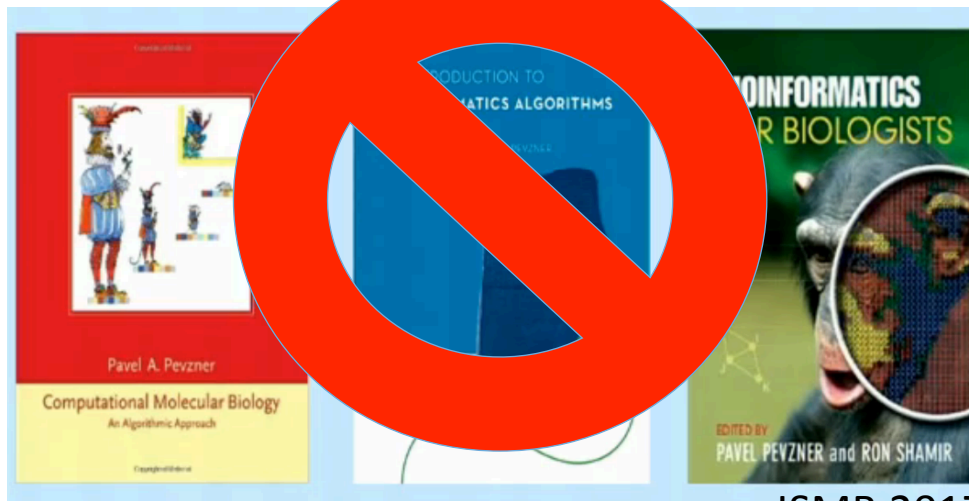


One-on-one education is best.

But we can't afford it, and if we could,  
there maybe are not enough tutors.

Instead, we should combine computers  
with teaching.

Pavel Pevzner





Pavel Pevzner

# Massive Adaptive Interactive Textbook

Online bioinformatics platform

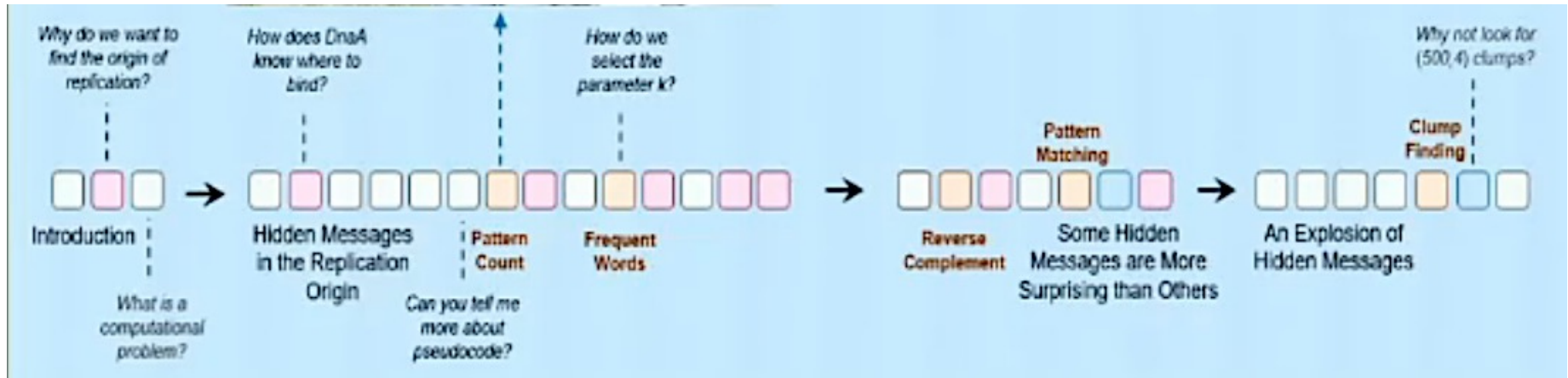
100+ autograded programming challenges

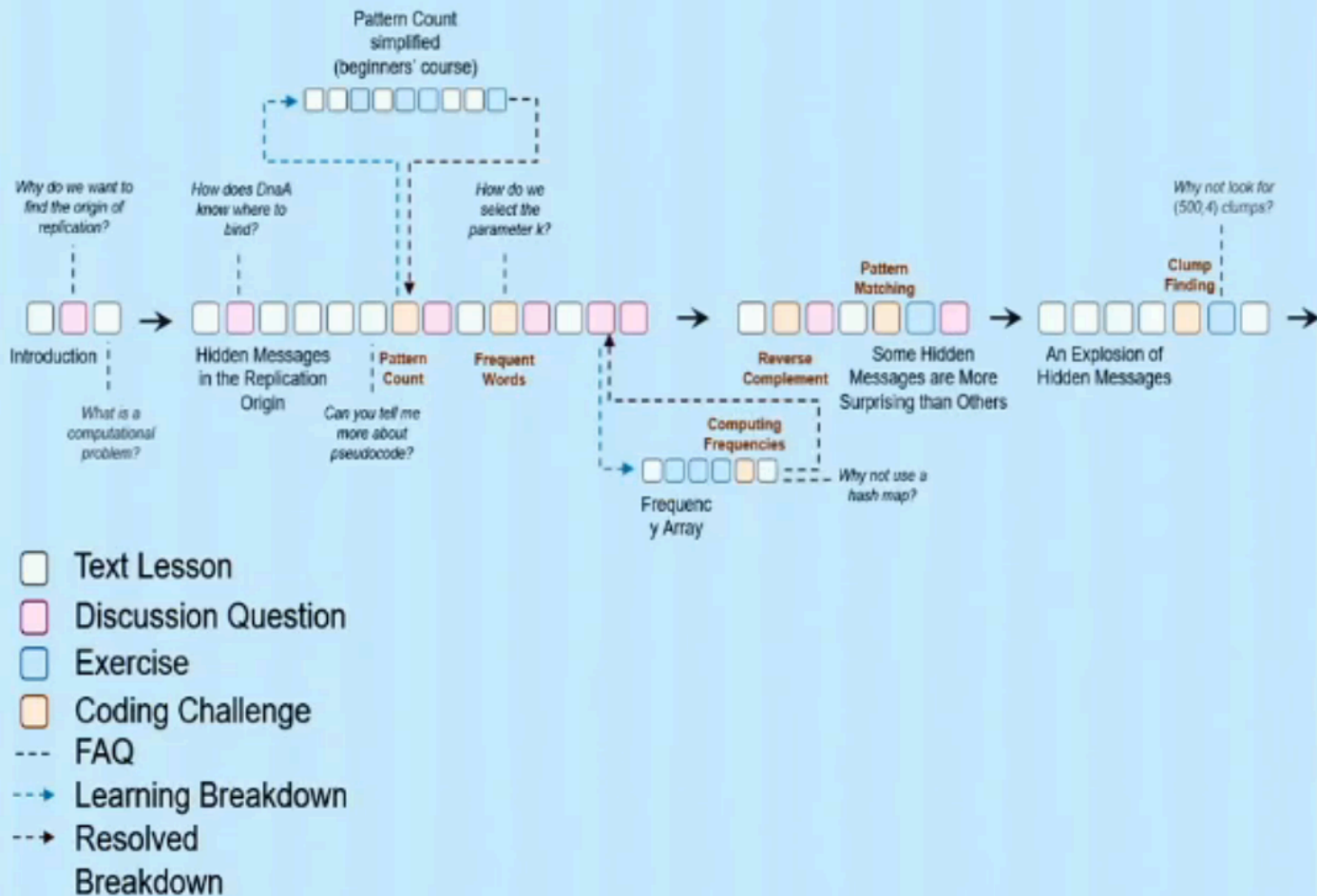
Stop and think exercises, code challenges, detours

As soon as a student fails, they are directed to a new module to address the learning breakdown.



# Programs, Challenges, FAQs throughout

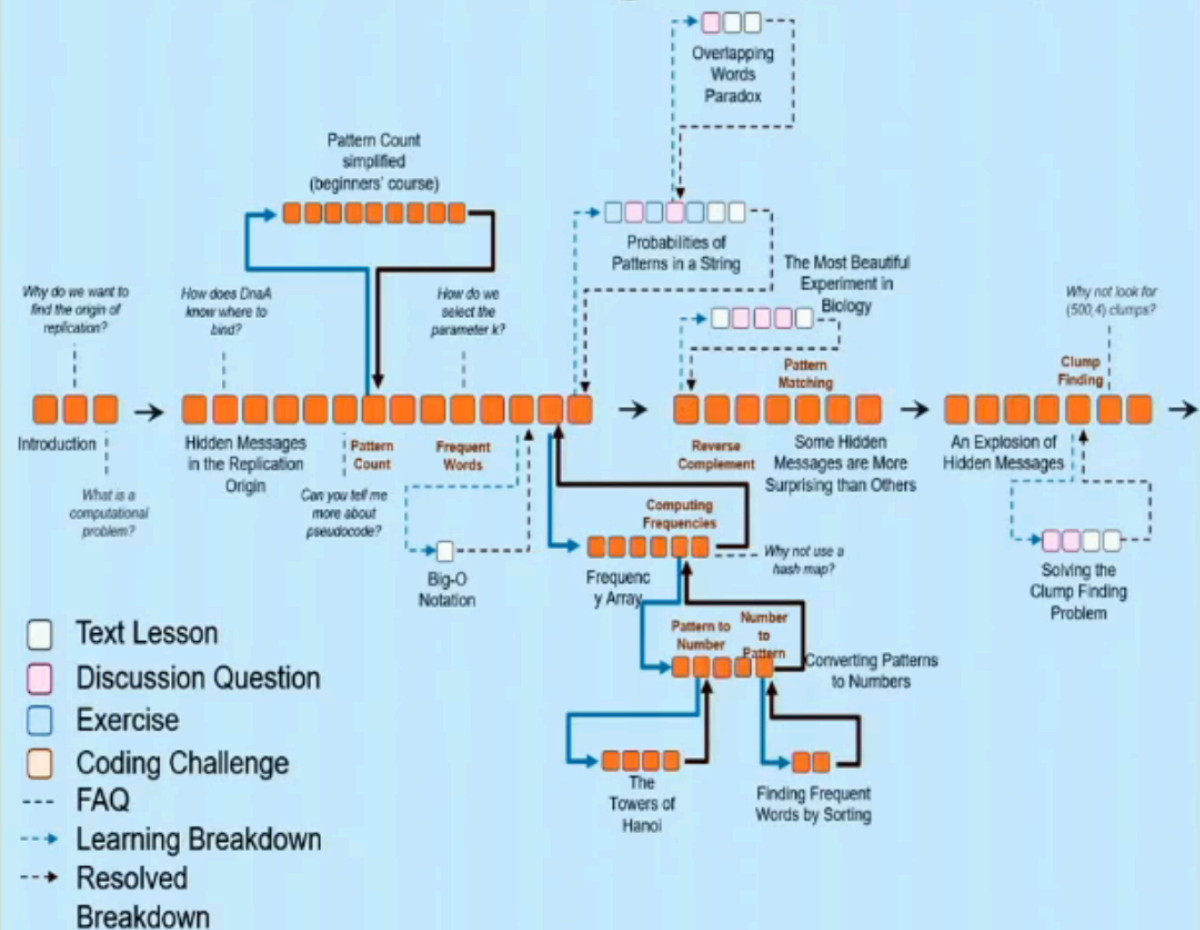




If a student makes an error, they are directed to a sub-branch to address the relevant misunderstanding.

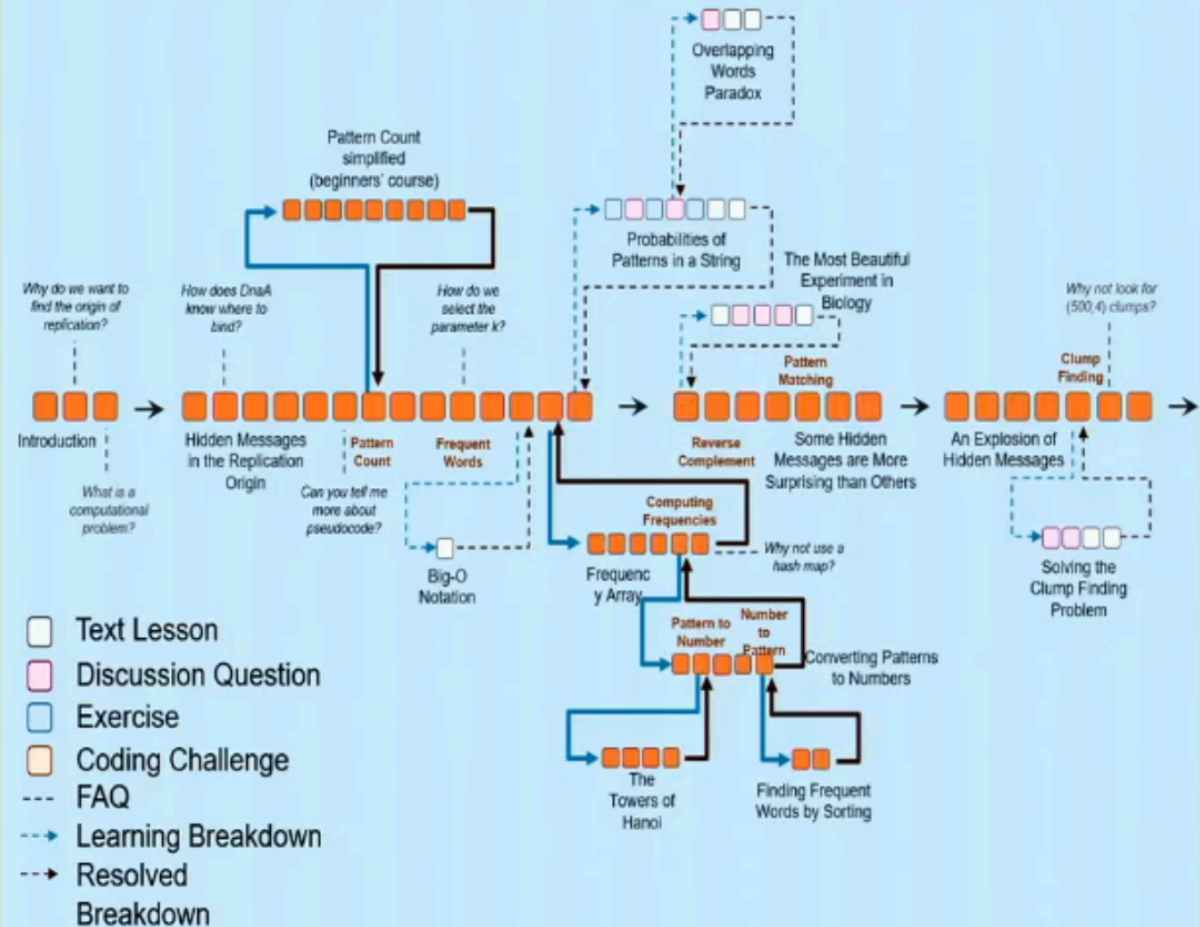


# Individual Learning Path (≈3 hours)



With thousands of students taking the course, more and more unexpected errors are uncovered.

# Individual Learning Path (≈3 hours)



**12 people  
and 7000  
hours  
development  
time already!**



Karthik  
Muralidharan

# Developing Countries' Perspective

- Hardware-focused interventions for home or school seem to have no positive impact on learning outcomes
- Pedagogy-focused computer-aided learning programs that allow students to review grade-appropriate content at their own pace do better, but gains are modest (.1-.2)
- Interventions that deliver the largest gains appear to be those that use technology to also personalize instruction.





Karthik  
Muralidharan

# MindSpark Deployment in India

- 10 years of development
  - >45,000 test questions
  - >1M questions administered per day
- Can tailor suggestions to students
- Student errors are analyzed to refine suggestions
- This allows for identification of long-tail misconceptions
- Show .36 learning gain in math and .22 in Hindi in randomized controlled studies.
- HOWEVER all of this tailoring work has been done manually.

# Long Tail Student Misperceptions: Which Number is Larger?



“27 is larger than 3”

# Long Tail Student Misperceptions: Which Number is Larger?



“ $1/27$  is larger than  $1/39$ ”

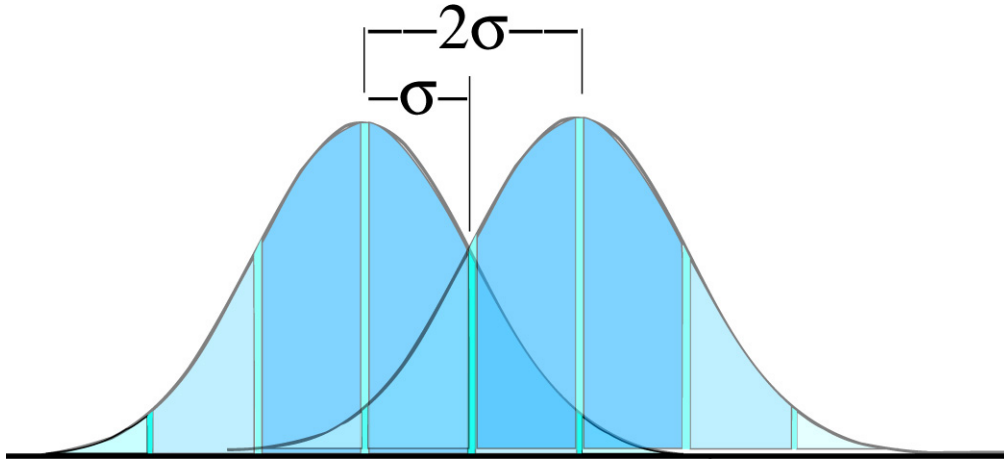
WE NEED TO ACCELERATE THIS:  
PEOPLE ARE DOING IT BY HAND!



THERE ARE MANY MORE EXAMPLES...

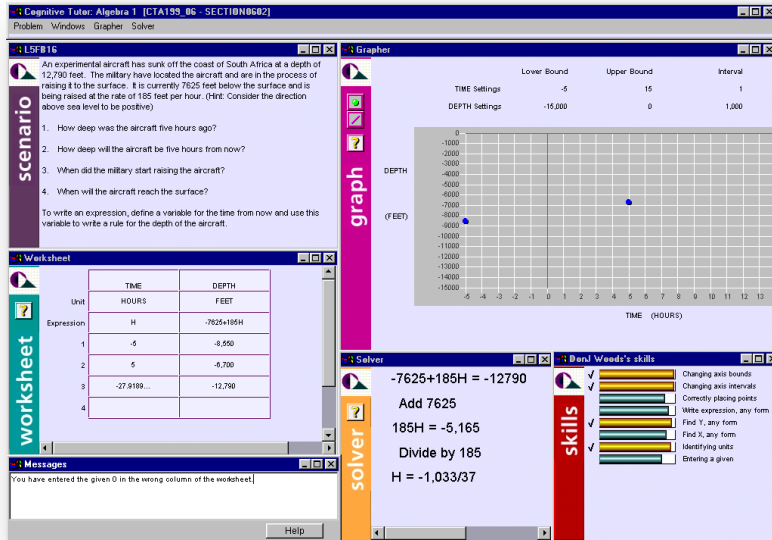
# AN EARLIER CHALLENGE

The average under tutoring [with mastery learning] was about two standard deviations above the average of the control. (Benjamin Bloom, 1984)\*

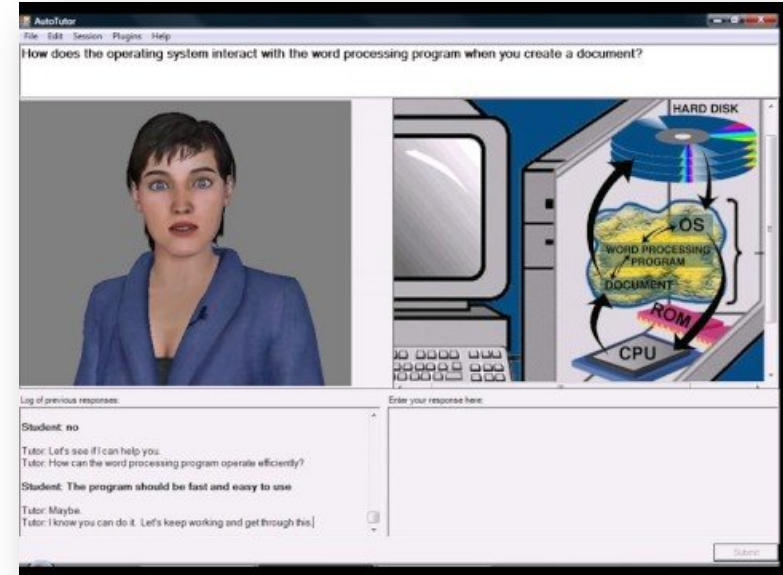


\*Subsequent analysis suggests (a) these cases were outliers, and (b) mastery learning was more important than tutoring, but it was a motivating challenge problem!

# Sophisticated Intelligent Tutoring Systems



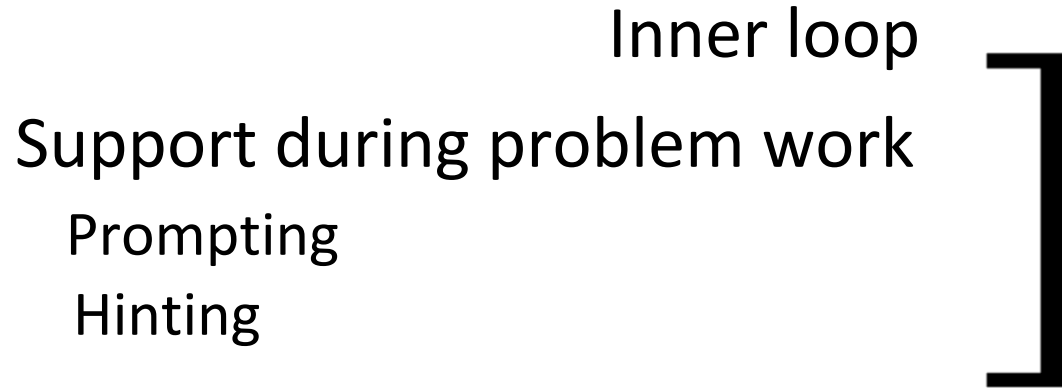
Cognitive Tutor (Algebra)



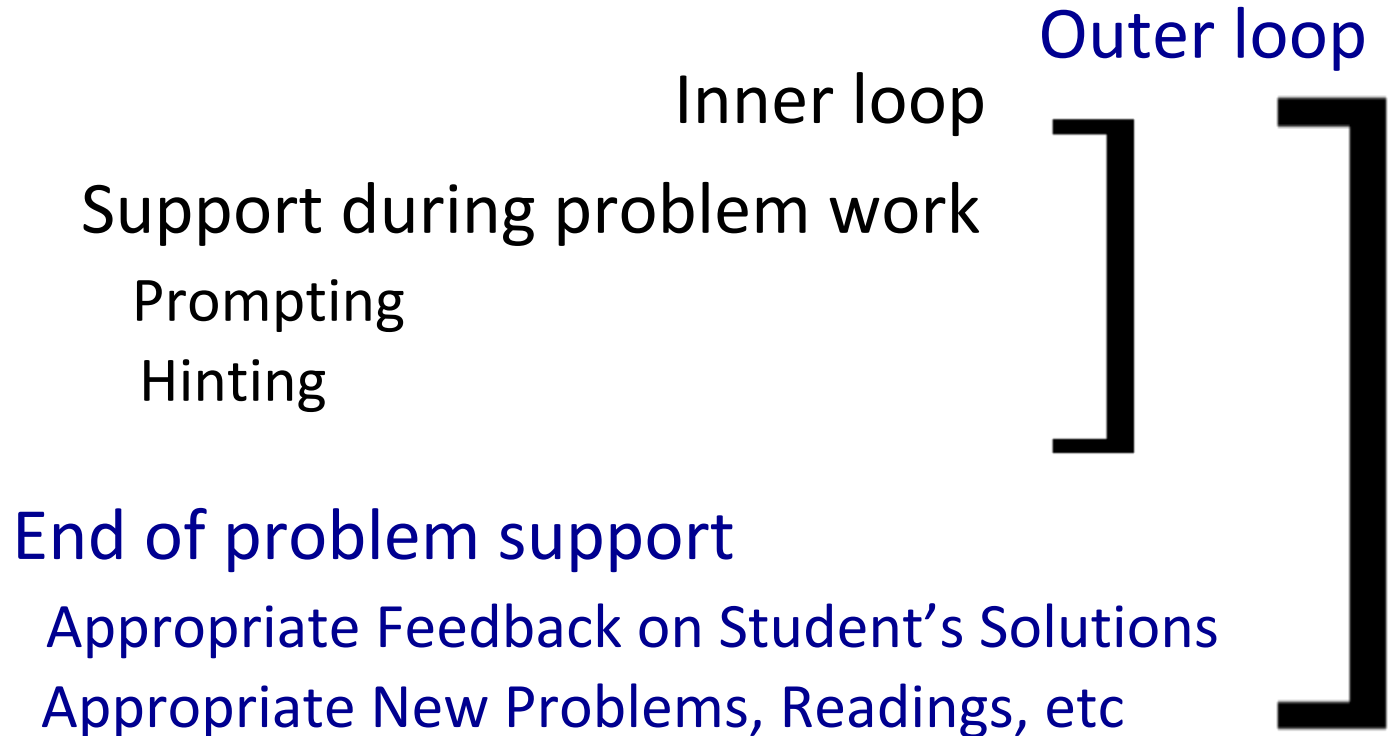
Autotutor



# Tutoring Systems: Interactive Feedback Loops



# Tutoring Systems: Interactive Feedback Loops



# Do Intelligent Tutoring Systems Work?

- Meta-meta-analysis (Kulik & Fletcher, Review of Educational Research, 2016)
  - Took into account important controlling factors
  - Found moderately strong positive effects (.4 - .6 typically)
  - An important factor was “adequacy of the program implementation”

“The evaluations show that ITS’s typically raise student performance well beyond the level of conventional classes and even beyond the level achieved by students who receive instruction from... human tutors.”

# WHY AREN'T INTELLIGENT TUTORING SYSTEMS DEPLOYED EVERYWHERE?



Claim: If There Were An Easy-to-Use Semi-Automated Way To Develop these Systems, People Would Use It

Why don't we have good software for developing autograders, hint generators, etc, for every topic ?



Ryan Baker

## “Stupid” Tutoring Systems, Intelligent Humans

The initial vision for intelligent tutoring systems involved powerful systems that would leverage rich user models to create complex learning interactions.

But the intelligent tutoring systems being used at scale today are much simpler.



Ryan Baker

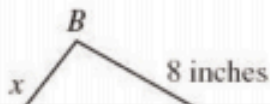
## “Stupid” Tutoring Systems, Intelligent Humans

Perhaps we do not in fact need intelligent tutoring systems. Perhaps instead what we need, what we are already developing, is stupid tutoring systems. Tutors that do not, themselves, behave very intelligently. But tutors that are designed intelligently, and that leverage human intelligence.



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What is the length of side DF in triangle DEF?

☐ Save Problem BodyProblem Type: Algebra 

## Answers

✓ 10

**✗** 5 You are almost right, but remember that DF is twice  $x$ .

 [New Answer](#)

### Hints

Hints are disabled when scaffolding is enabled. Clicking on "Enable Hints for the problem"

### ▼ Main Problem

▼ Which side of tri...

▼ What is the perim...

What the content developer sees

1st scaffold

### 2nd scaffold

**What the student sees**

<http://assistment3.cs.wpi.edu/> · Assistment · Previewing Content · Windows Internet Explorer

Triangles ABC and DEF are congruent.  
The perimeter of triangle ABC is 23 inches.  
What is the length of side DF in triangle DEF?



### The original question

Reduced authoring of 1 hour of content from 200 hours to 40 hours!

Submit Answer

# ASSISTments

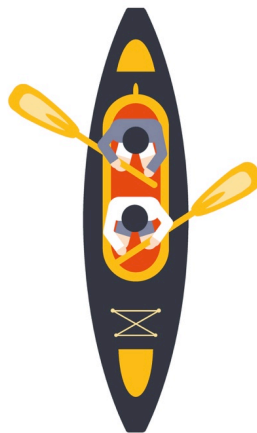
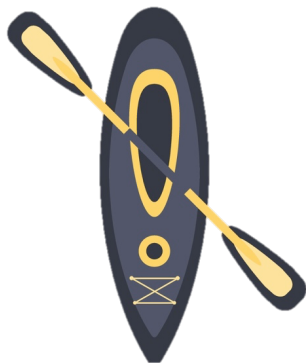
# Learning:

## The Ideal Laboratory for Core AI Problems

- Machine Learning
- Knowledge Representation
- Reasoning
- Natural Language Processing
- Image and Video Analysis
- Cognition
- Neuro-X

# Opportunities for AI to Intersect with Learning

Generating Hints  
From Existing  
Rationales



Reproducing  
Peer Learning  
Online



# MOONSHOT: Accelerate Learning



# Moonshot: Accelerate Learning

How to get a quantum leap in performance?

Can AI be Part of the solution?



# To Accelerate Human Learning Beyond What Is Possible Today

To reach 2-sigma goal,  
Automation and expertise  
Academia and industry together might be the key.



**Thank you!**

Marti Hearst  
UC Berkeley