

LIFE AFTER MOOCS

*Online Science Education
Needs a New Revolution**

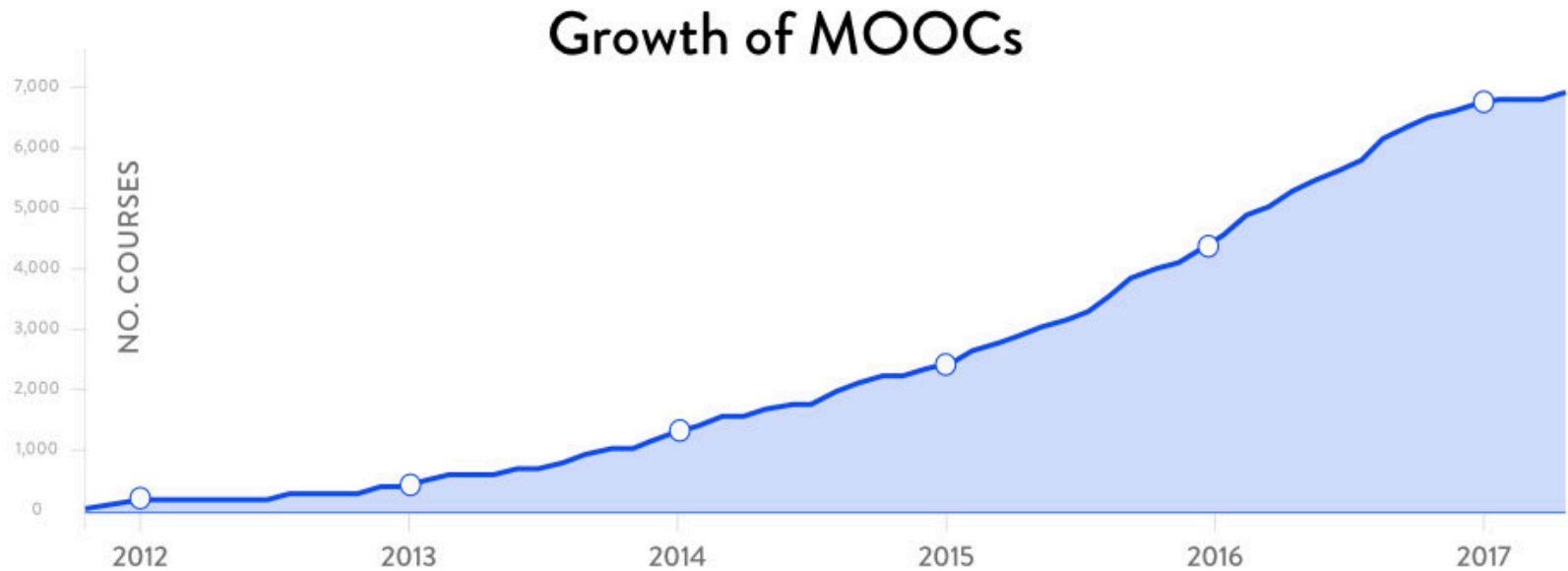
Phillip Compeau



Appeared in *Communications of the ACM* (with Pavel Pevzner), Oct. 2015

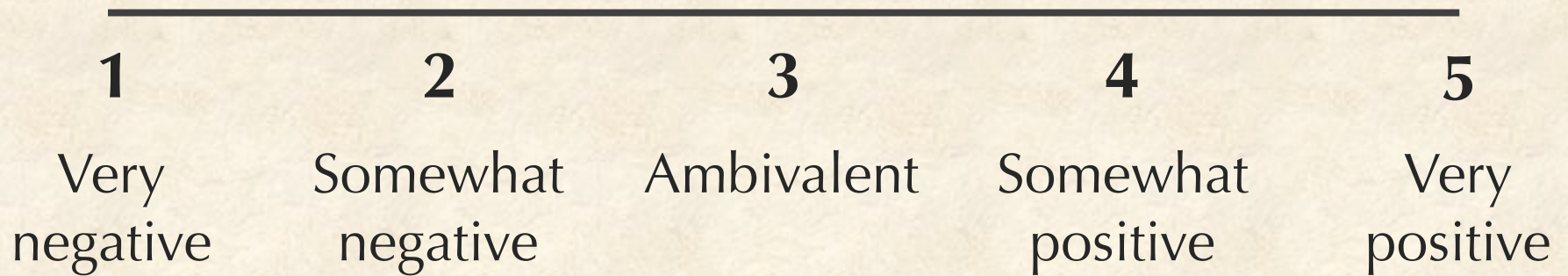
Massive
Open
Online
Course

Growth of MOOCs



Source [CLASS CENTRAL](#)

What Is *Your* Feeling About MOOCs?



Outline

- What Brings Me Here
- What is Wrong with MOOCs?
- From MOOCs to MAITs
- Meet Our Students
- Sustaining a Million-Dollar MAIT
- Future Directions
- “My MAIT is a Better Teacher than I am!”



(rosalind.info)

Browser window showing the Rosalind website interface. The URL is rosalind.info/problems/list-view/. The page title is "Problems".

Navigation: About, Problems, Statistics, Glossary, Problem ID..., Facebook, Twitter, pricklypete, Log out

Problems

Rosalind is a platform for learning bioinformatics through problem solving. [Take a tour](#) to get the hang of how Rosalind works.

Last win: [illbehereallday](#) vs. "Counting DNA Nucleotides", 4 minutes ago

Problems: 89 (total), users: 3644, attempts: 51607, correct: 31129

ID	Title	Solved By	Correct ratio	Questions	Solutions
DNA	Counting DNA Nucleotides	3644	<div style="width: 100%; height: 10px; background-color: green;"></div>	1 day, 19 hours	3 hours, 21 minutes
RNA	Transcribing DNA into RNA	3121	<div style="width: 100%; height: 10px; background-color: green;"></div>		
REVC	Complementing a Strand of DNA	2825	<div style="width: 100%; height: 10px; background-color: green;"></div>		
GC	Computing GC Content	1606	<div style="width: 50%; height: 10px; background-color: orange;"></div>		
HAMM	Counting Point Mutations	2188	<div style="width: 100%; height: 10px; background-color: green;"></div>		
SUBS	Finding a Motif in DNA	1621	<div style="width: 50%; height: 10px; background-color: orange;"></div>		
GRPH	Overlap Graphs	768	<div style="width: 50%; height: 10px; background-color: orange;"></div>		
IPRB	Mendel's First Law	201	<div style="width: 100%; height: 10px; background-color: green;"></div>		
LCS	Finding a Shared Motif	581	<div style="width: 100%; height: 10px; background-color: green;"></div>		
MPRT	Finding a Protein Motif	100	<div style="width: 20%; height: 10px; background-color: orange;"></div>		
PERM	Enumerating Gene Orders	1266	<div style="width: 100%; height: 10px; background-color: green;"></div>		
PROT	Protein Translation	1461	<div style="width: 100%; height: 10px; background-color: green;"></div>		
REVP	Locating Restriction Sites	592	<div style="width: 100%; height: 10px; background-color: green;"></div>		
IEV	Calculating Expected Offspring	118	<div style="width: 100%; height: 10px; background-color: green;"></div>		
LEXF	Enumerating k-mers Lexicographically	588	<div style="width: 100%; height: 10px; background-color: green;"></div>		
LIA	Independent Alleles	45	<div style="width: 100%; height: 10px; background-color: green;"></div>		

[Feedback](#)

Here's the list of Rosalind problems

Click to see the first problem.

R SALIND Statistics

- 284 problems in 5 different “locations”
- 168,000 signups
- 43,000 users solving at least one problem
- 414,000 correct submissions
- Used 375 times by 100+ different instructors

Rosalind Statistics

- 284 problems in 5 different “locations”
 - 168,000 signups
 - 43,000 users solving at least one problem
 - 414,000 correct submissions
 - Used 375 times by 100+ different instructors
-
- But...Rosalind is not a standalone educational resource!





Bioinformatics Algorithms MOOCs

- 2013: First bioinformatics MOOC
- August 2015: Bioinformatics Specialization
 1. Finding Hidden Messages in DNA
 2. Genome Sequencing
 3. Comparing Genes, Proteins, and Genomes
 4. Deciphering Molecular Evolution
 5. Genomic Data Science and Clustering
 6. Finding Mutations in DNA and Proteins
 7. Capstone: Big Data in Biology (sponsored by Illumina)

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Criticisms of MOOCs

COMMUNICATIONS
OF THE
ACM

11/2012

Will MOOCs Destroy Academia?

The New York Times

5/2013

**Professors at San Jose State
Criticize Online Course**

Slate

7/2013

The MOOC Racket:
Widespread online-only higher ed
will be disastrous for students —
and most professors.

THE CHRONICLE
of Higher Education

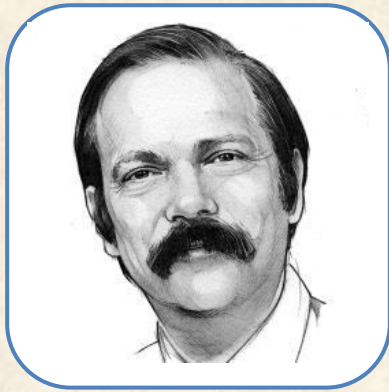
7/2013

A MOOC Delusion:
Why Visions to Educate the
World are Absurd

Criticisms of MOOCs

COMMUNICATIONS
OF THE
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Will MOOCs Destroy Academia?



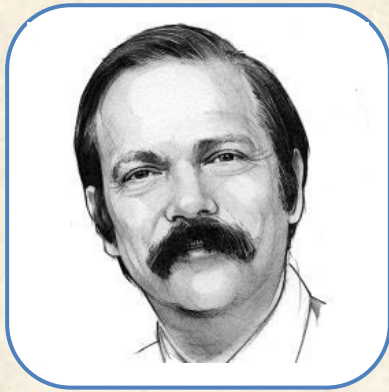
Vardi, 2012

“If I had my wish, I would wave a wand and make MOOCs disappear.”

Criticisms of MOOCs

COMMUNICATIONS
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ACM

Will MOOCs Destroy Academia?



Vardi, 2012

*"If I had my wish, I would wave a wand and make MOOCs **disappear**."*



Trithemius, 1492

*"The printed book is made of paper, and like paper, will soon **disappear**."*

Which Would You Prefer?



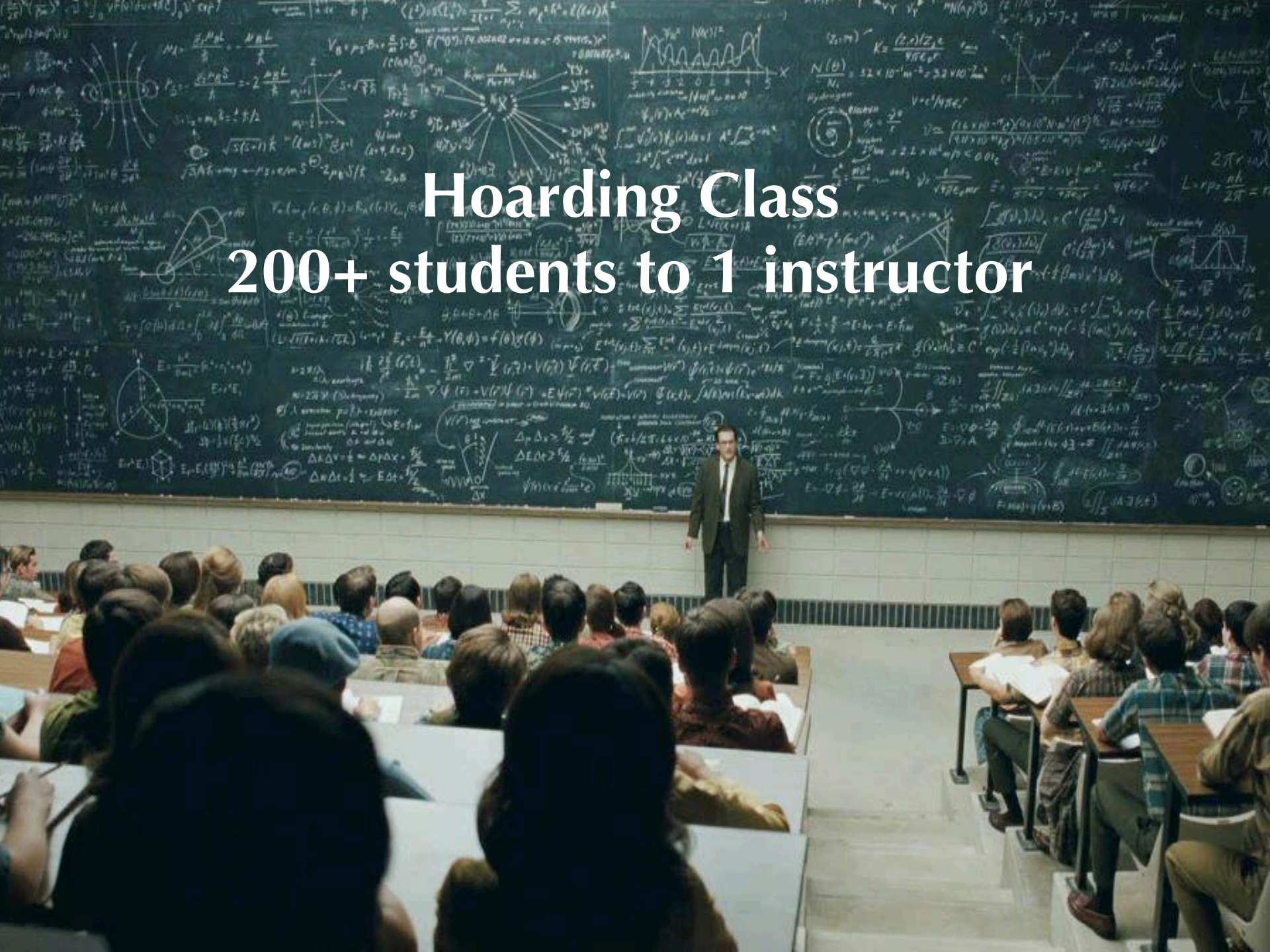
OR

Of one she knoweth not the condiaon
 Husbondis been alle gode andy haue he yore
 That knowe wyue J dar say nomore
 For she saye thy wretched childe custauce
 Thy yonge daughter fostredy by so fofte
 That most you loueth with obissance
 Quir alle thynge out take crist on losse
 Custauce your childe her recomandith ofte
 Onto your grace for J shal to surye
 Me shal J neuer se you more with ye
 Allas vnto the barbarik nation
 J muste anon acordyng to your wil
 But crist that deye for our redempcion
 So yave me grace his bestis to fulfille
 J wretched womman no fore though J spylle
 Wommen are born to thral dom e to penaunce
 Andy to be vnder manys gouernaunce
 J twold at troye whay Turmus had the wal
 Of Troy nor brent was theles the cyt
 Me Rome for the sege of hampshal
 That Romayns hadde kengupshedy tymes thre
 Mas herd suche tender wepyng for pyte
 As was in the chambir for her departyng
 But forth she moot wether she wepe or spynge
 O frosty moornyng cruel firmament
 With thy dyurnal whele that coldest ay
 Andy hurtelist al fro este to occident
 That naturelly wolde holde another wep
 Thy coldyng set the leuen in suche way

l'union de yvesse

Hoarding Class

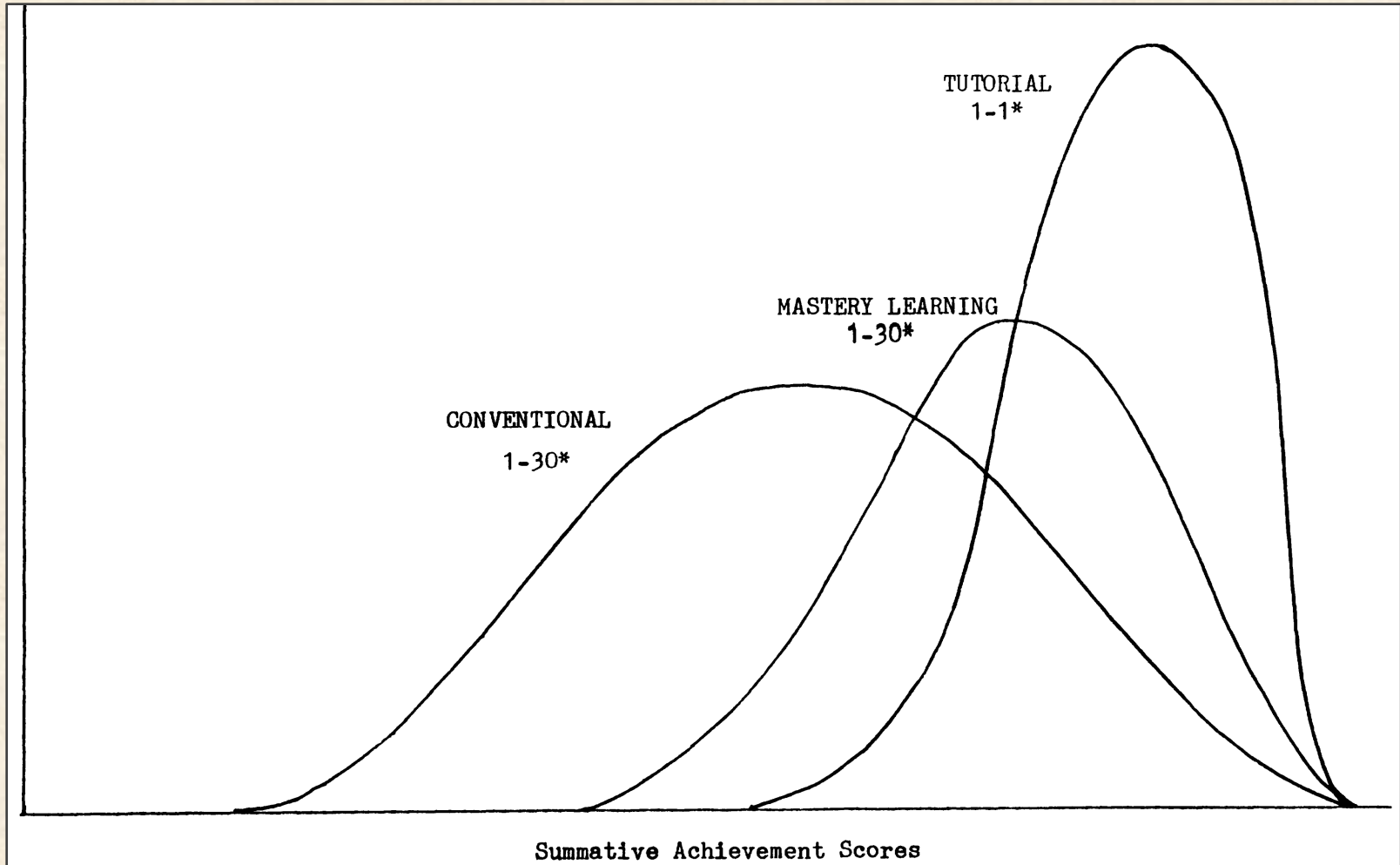
200+ students to 1 instructor



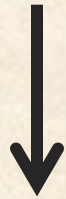
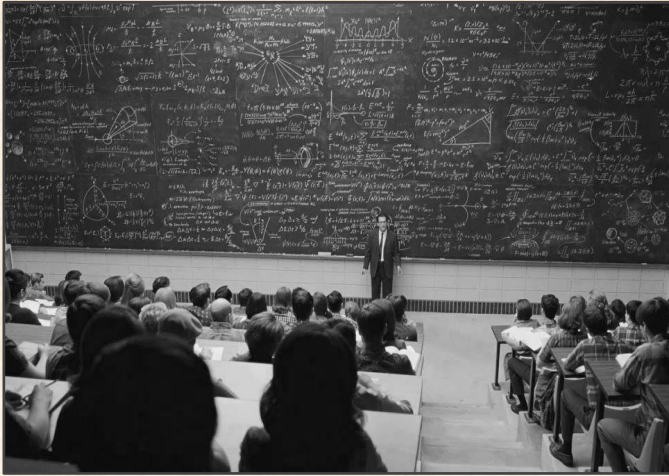
Learning Breakdown



Bloom's 2σ Problem (1984)







Massive
Open
Online
Course



Massive
Adaptive
Interactive
Text

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Kolowich 2013:
~100 hours spent
before launch of
typical MOOC

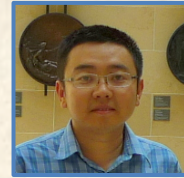
Massive Development Resources



Nikolay Vyahhi
Rosalind founder,
Stepic CEO,
co-instructor



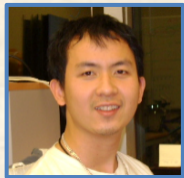
Olga Botvinnik
course/graphics
development



Yu Lin, Ph.D.
course
development



**Randy
Christopher**
resident artist



Son Pham, Ph.D.
invited lecturer,
course developer



Max Shen
course/software
development



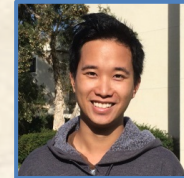
Robin Betz
course
development



Lars Bernstein
course
development



Kai Zhang
chief assessment
programmer



Vu Ngo
course/software
development



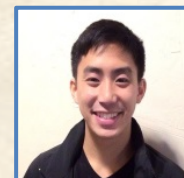
Mark Mammel
teaching asst,
content review



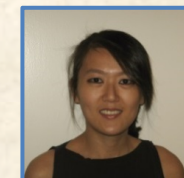
**Glenn Tesler,
Ph.D.**
content
review



Alexei Balandin
chief Rosalind
programmer



Jeffrey Yuan
course/software
development



Isabel Lupiani
teaching asst,
content review



Sangtae Kim
invited
lecturer

Massive Development Resources



2013-2014



2013-2014



2014-2015

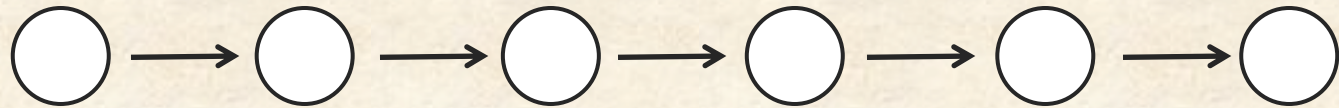


2015-2018

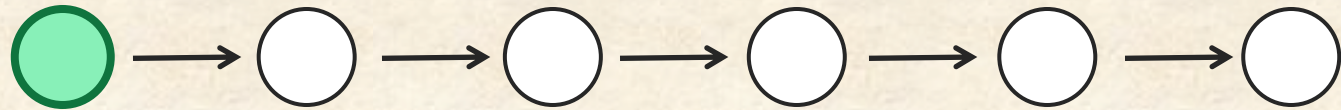
The “ $\frac{1}{2}\sigma$ Problem”

- Freeman et al., 2014: Active learning increases student performance by $\frac{1}{2}\sigma$ over traditional instruction.
- All assessments are integrated into our courses as soon as they are needed:
 - STOP and Think questions
 - Exercise Breaks
 - Code Challenges
 - Final Data Challenges
- **How can we move from a $\frac{1}{2}\sigma$ to a 2σ improvement?**

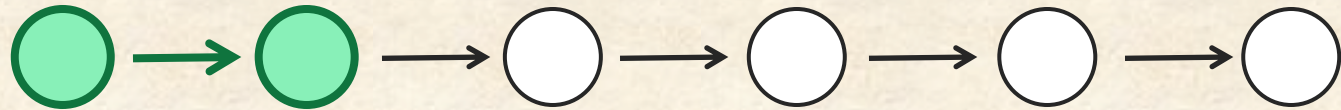
From Active to **A**daptive Learning



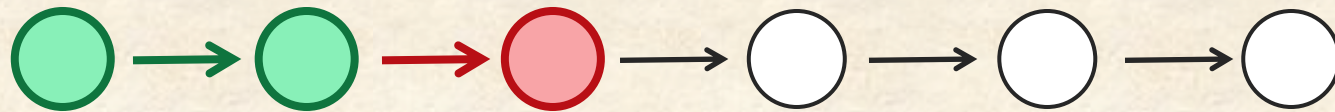
From Active to **A**daptive Learning



From Active to **A**daptive Learning



From Active to **A**daptive Learning



**Learning
Breakdown**

From Active to **A**daptive Learning



**Learning
Breakdown**

From Active to **A**daptive Learning



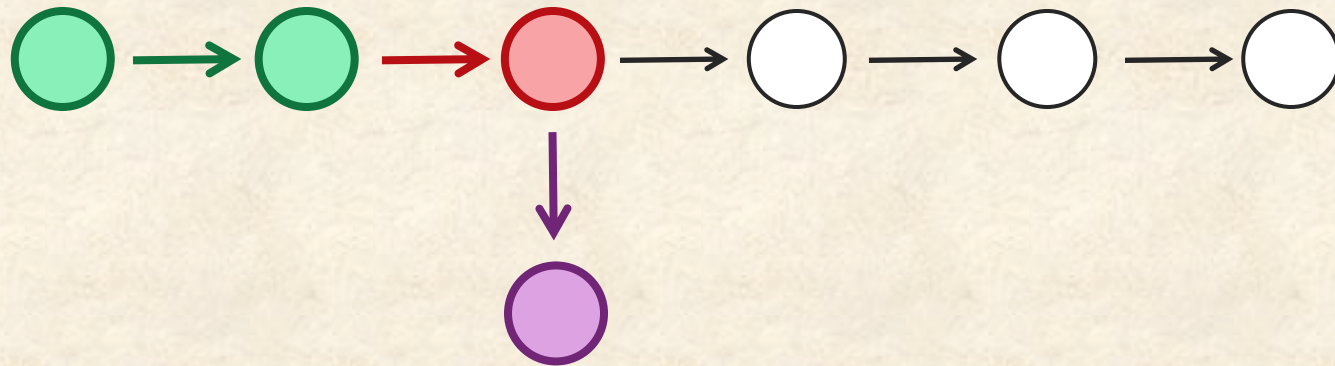
**Learning
Breakdown**

From Active to **A**daptive Learning

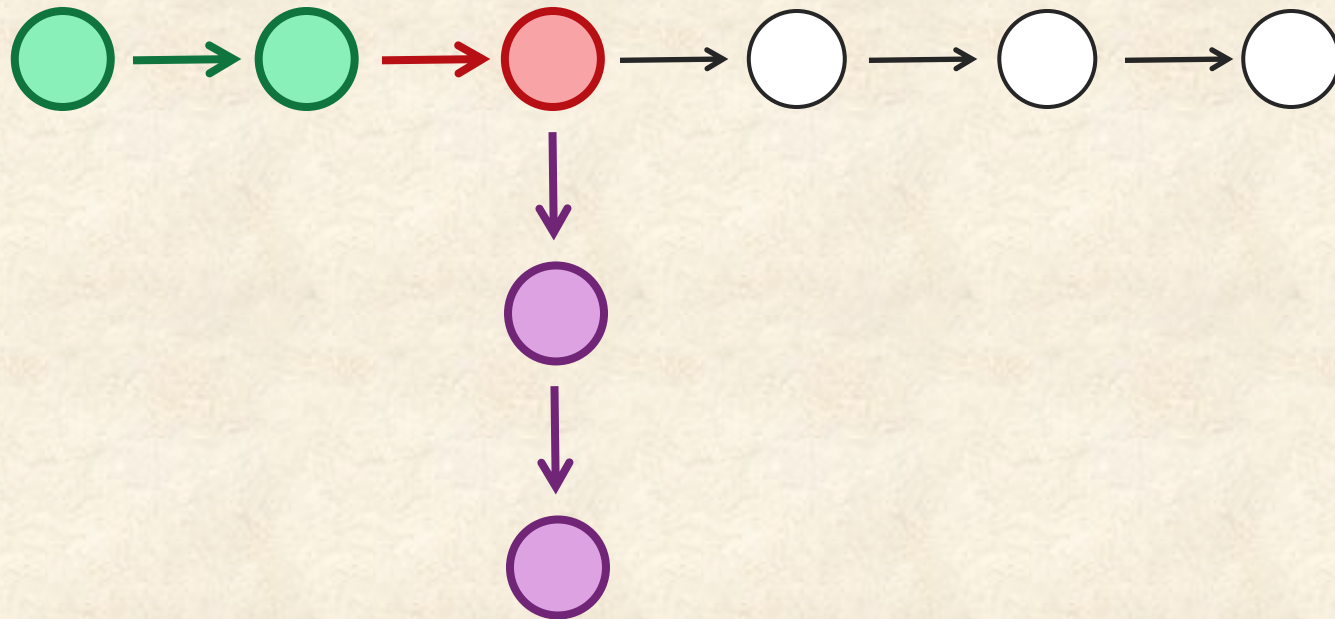


**Learning
Breakdown**

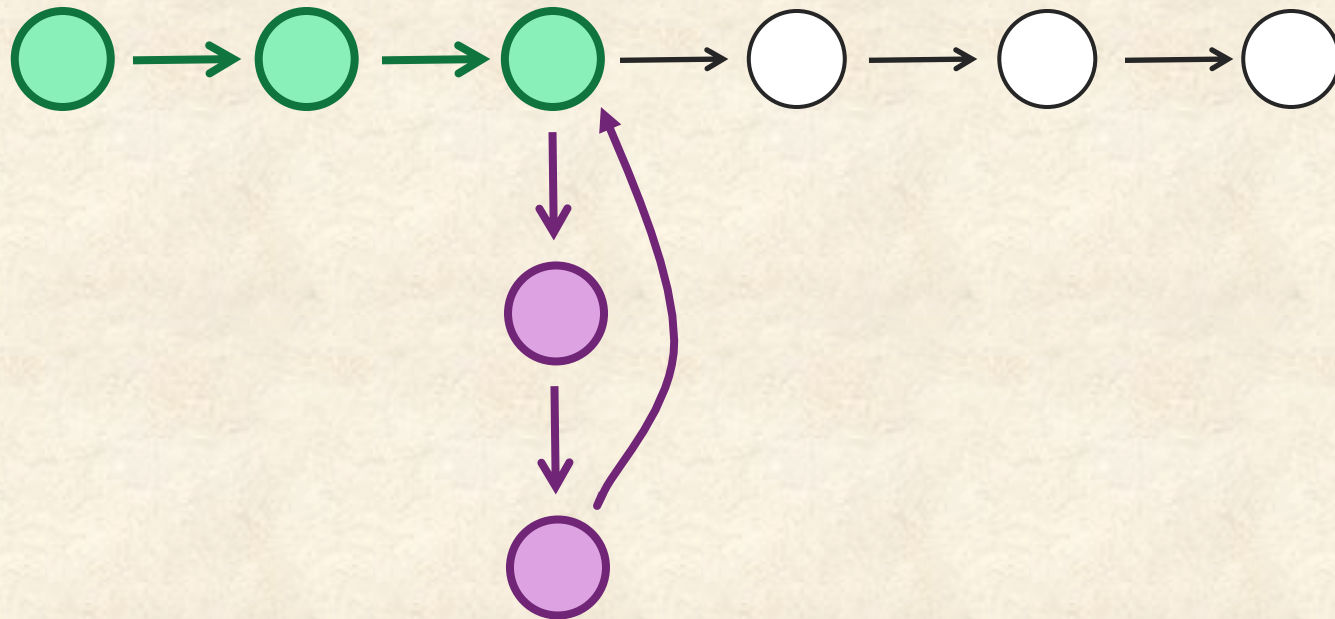
From Active to **A**daptive Learning



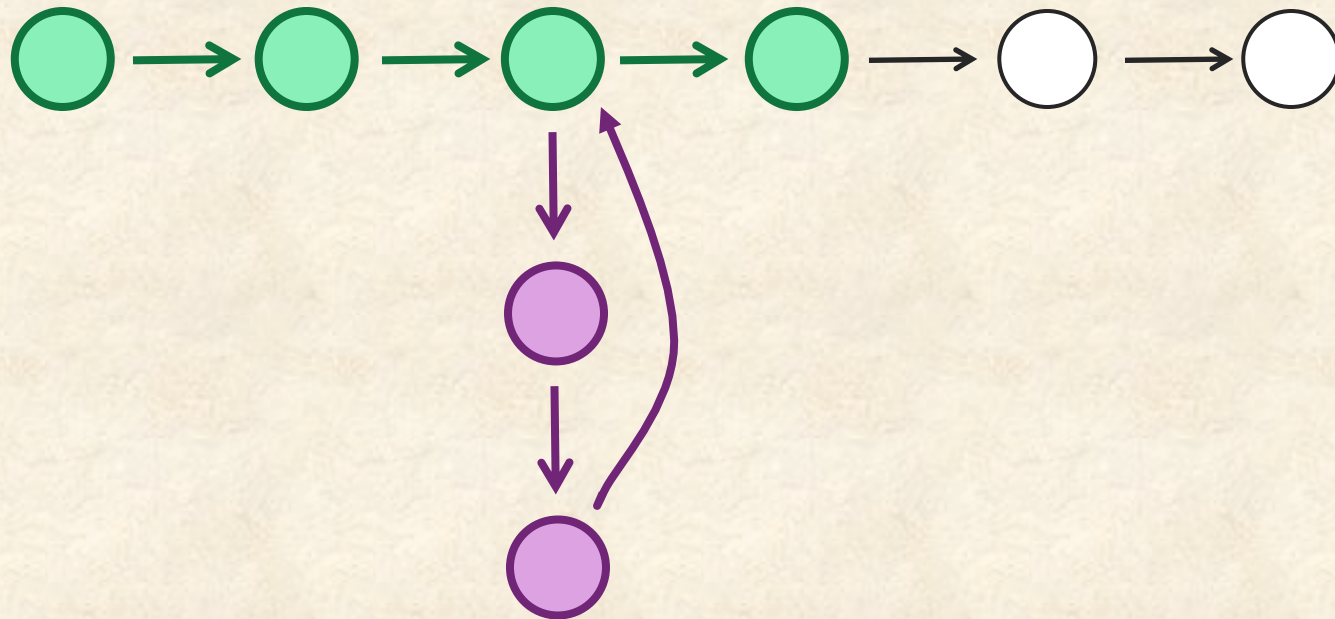
From Active to **A**daptive Learning



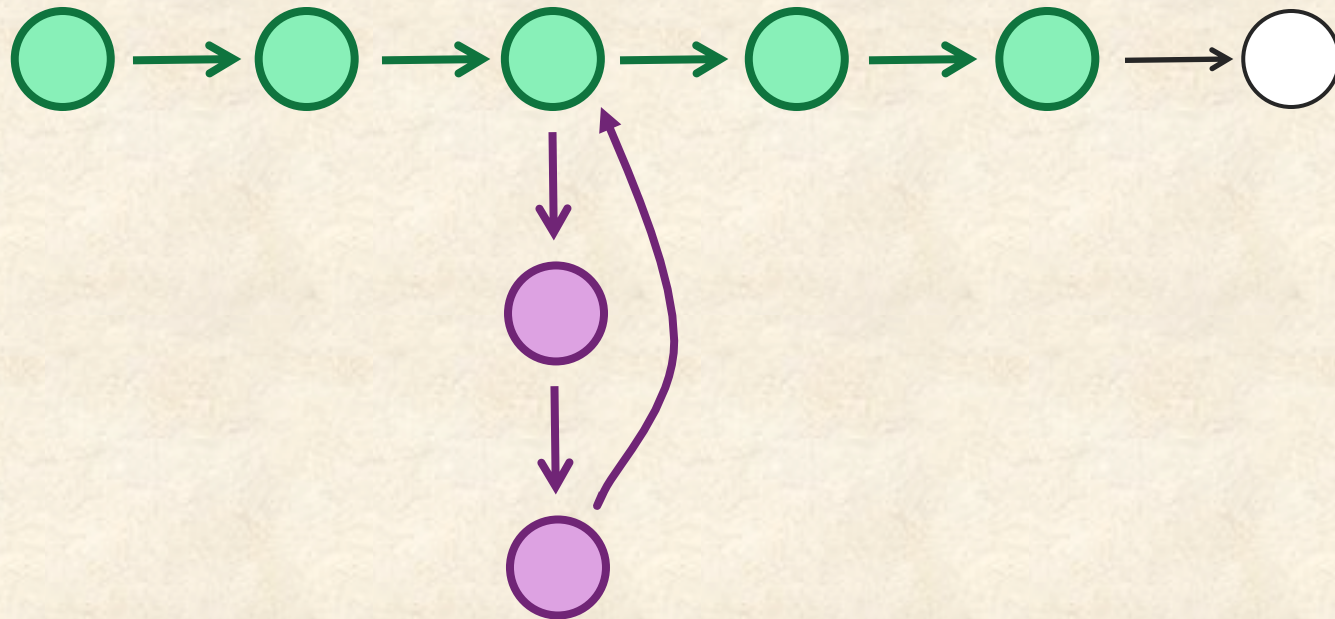
From Active to **A**daptive Learning



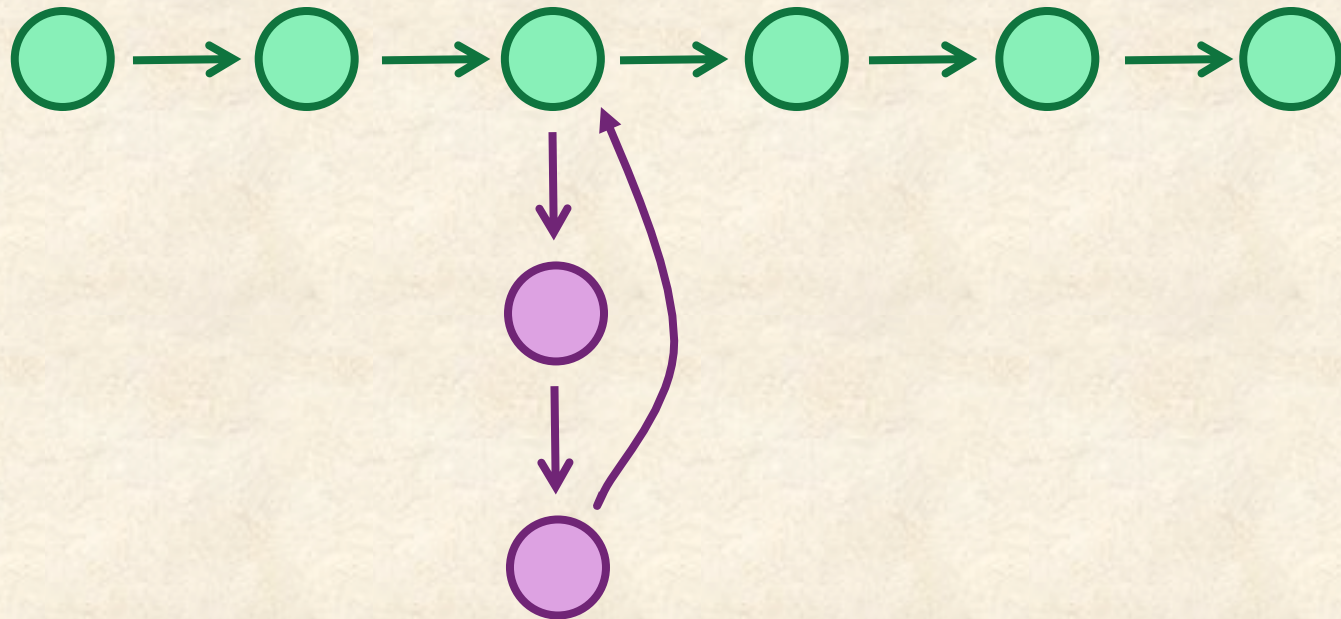
From Active to **A**daptive Learning



From Active to **A**daptive Learning

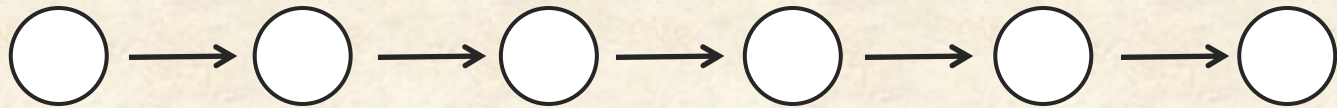


From Active to **A**daptive Learning

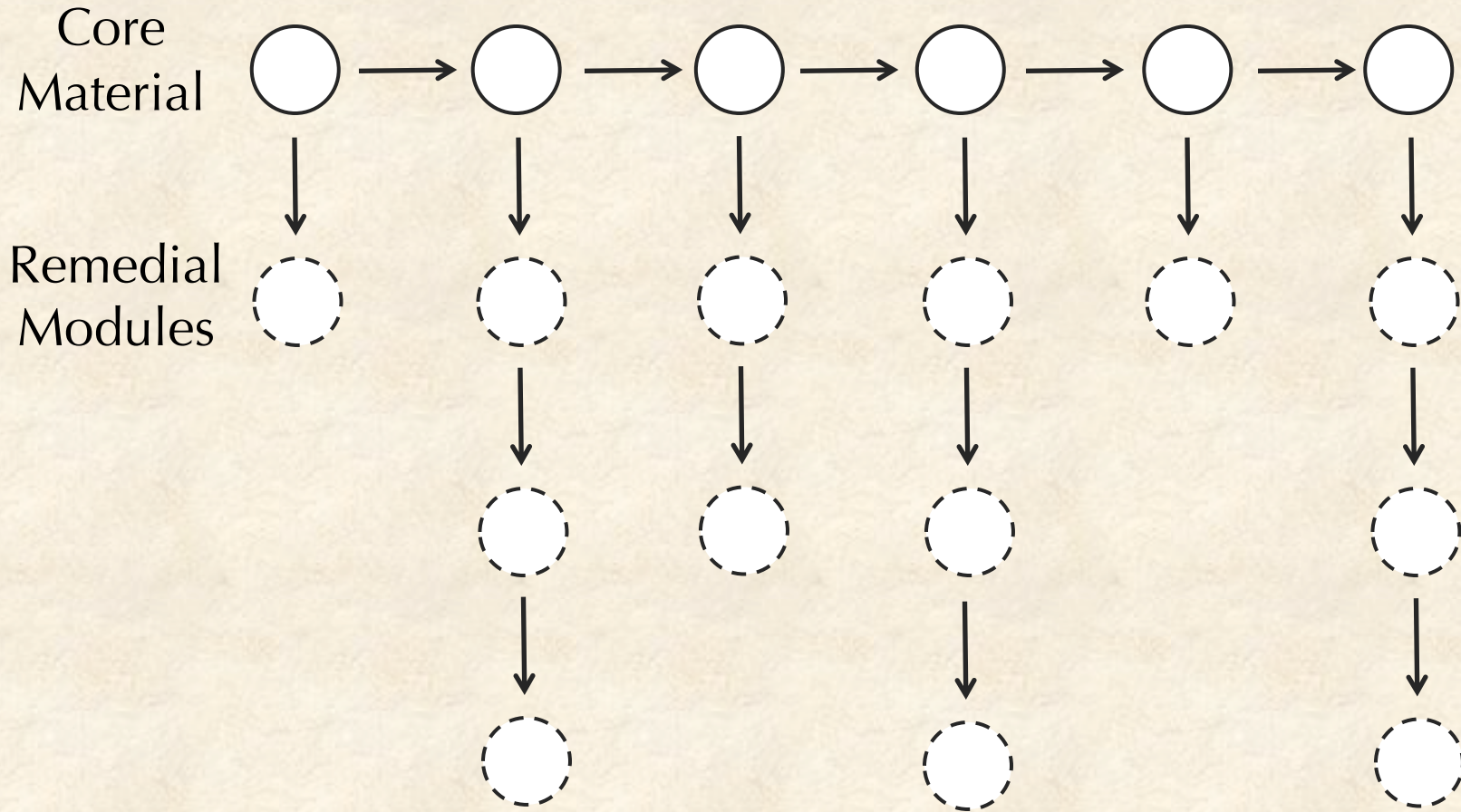


From Active to **A**daptive Learning

Core
Material



From Active to **A**daptive Learning



Compendium of Learning Breakdowns

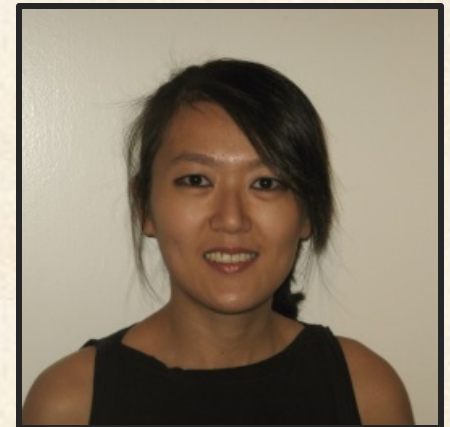
- First run of first three courses (12 weeks):
 - 8,500 discussion forum posts: **4,400 pages**
 - compendium of learning breakdowns: **42 pages**
 - changes to courses based off student issues: **128 pages**

Compendium of Learning Breakdowns

Pattern Matching Problem: Find all starting positions of a word (*DnaA* box) in a text (origin of replication).

CTCGGAGCGA**CTCTC**GGTCAGTGAGTT**CTC**AGTCGACTTTA**CTC**
0 10 12 27 41

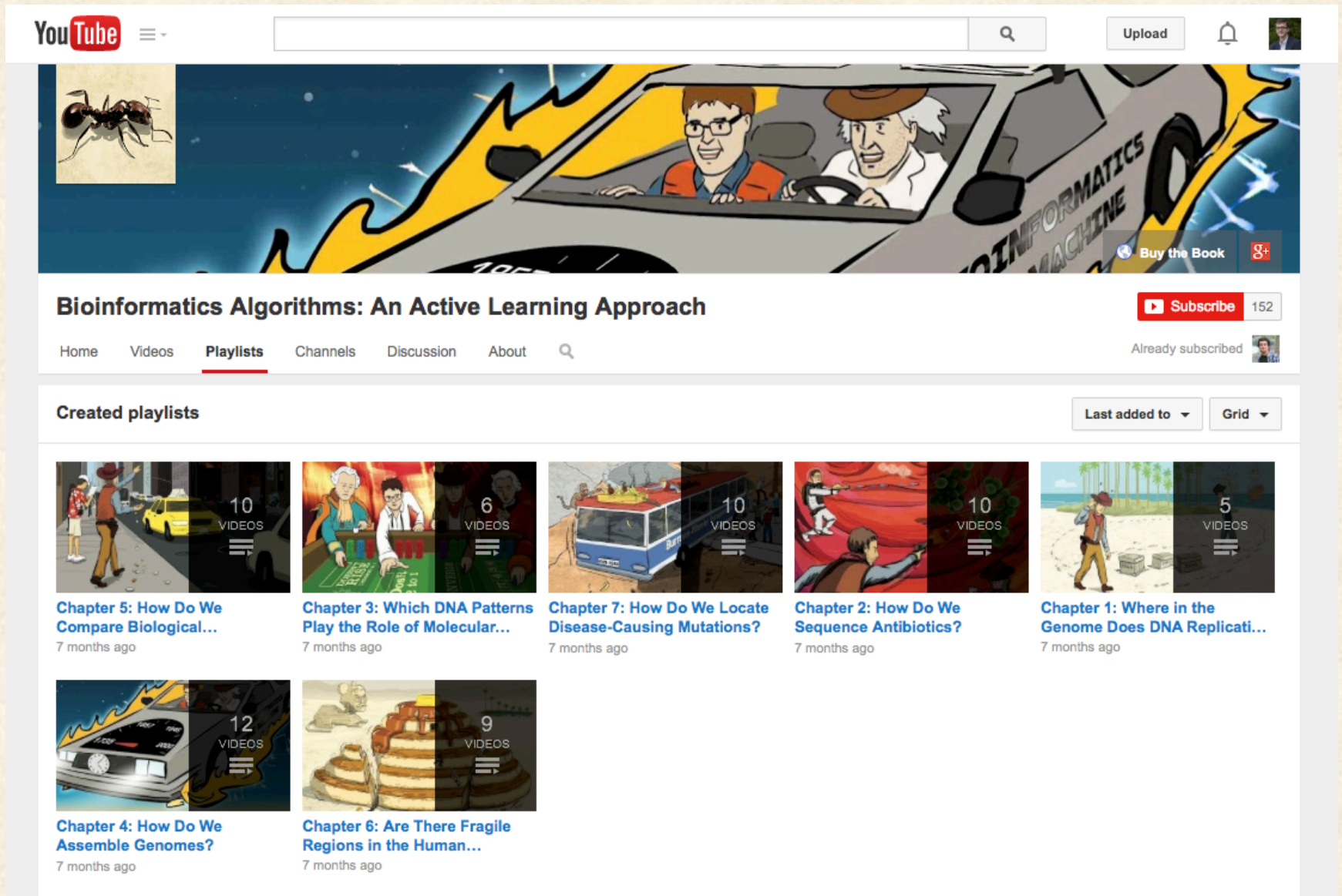
- Swap text and word in input (0 occurrences)
- Miss overlapping occurrences of word
- Miss strings at beginning or end of text
- Read too far ahead in text and include counts accrued in the reverse complement of text.
- Identify only the first occurrence.
- Identify only the last occurrence.
- Use 1-based indexing instead of 0-based indexing



Toward an **I**nteractive Content System

- There is an entire research field in **intelligent tutoring systems** (dating to LISP interactive tutors developed in 1982).
- But financial barriers have meant this research has rarely moved beyond K-12 or introductory undergraduate STEM classes.

Text-Based Content



The image shows a YouTube channel page for 'Bioinformatics Algorithms: An Active Learning Approach'. The channel banner features a cartoon illustration of two men in a car, with the text 'BIOINFORMATICS MACHINE' on the side. The channel name is 'Bioinformatics Algorithms: An Active Learning Approach' and it has 152 subscribers. The page displays a list of 10 videos, each with a thumbnail and a title. The videos are arranged in two rows of five. The first row includes Chapter 5, Chapter 3, Chapter 7, Chapter 2, and Chapter 1. The second row includes Chapter 4 and Chapter 6. Each video thumbnail shows a different scene related to the chapter's topic, such as a car, a bus, a person, and a stack of books.

Bioinformatics Algorithms: An Active Learning Approach [Subscribe](#) 152

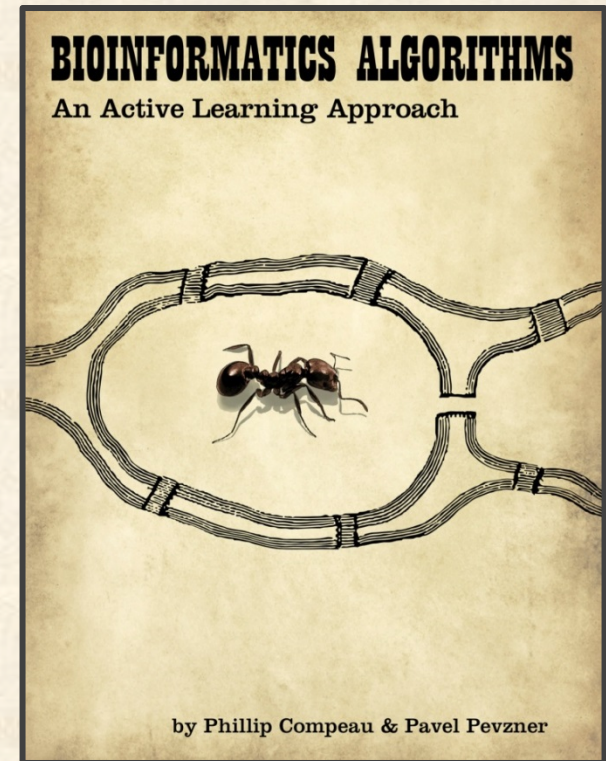
Home Videos **Playlists** Channels Discussion About

Created playlists [Last added to](#) [Grid](#)

- Chapter 5: How Do We Compare Biological...** 10 VIDEOS 7 months ago
- Chapter 3: Which DNA Patterns Play the Role of Molecular...** 6 VIDEOS 7 months ago
- Chapter 7: How Do We Locate Disease-Causing Mutations?** 10 VIDEOS 7 months ago
- Chapter 2: How Do We Sequence Antibiotics?** 10 VIDEOS 7 months ago
- Chapter 1: Where in the Genome Does DNA Replicati...** 5 VIDEOS 7 months ago
- Chapter 4: How Do We Assemble Genomes?** 12 VIDEOS 7 months ago
- Chapter 6: Are There Fragile Regions in the Human...** 9 VIDEOS 7 months ago

Text-Based Content

- Adopted for use in 50 universities (and three high schools!) since fall 2014

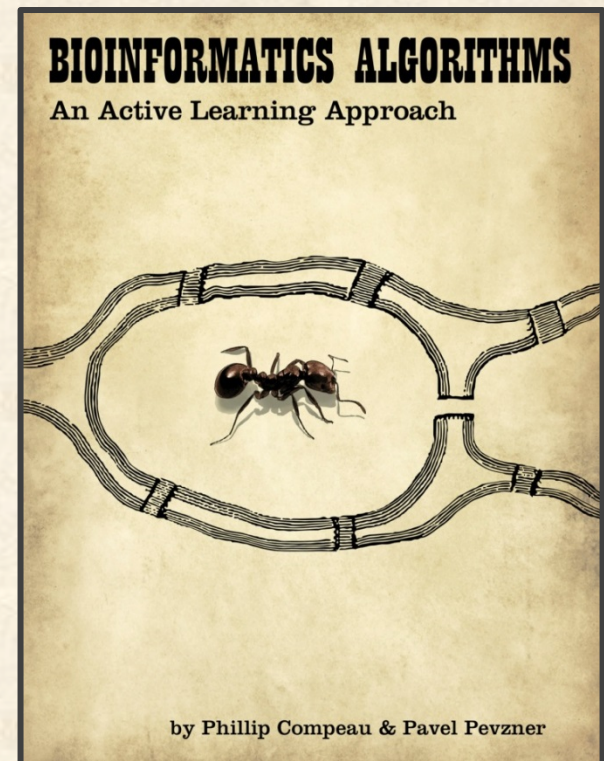


Text-Based Content

- Coursera courses are powered by a completely interactive version of this textbook with remedial modules.

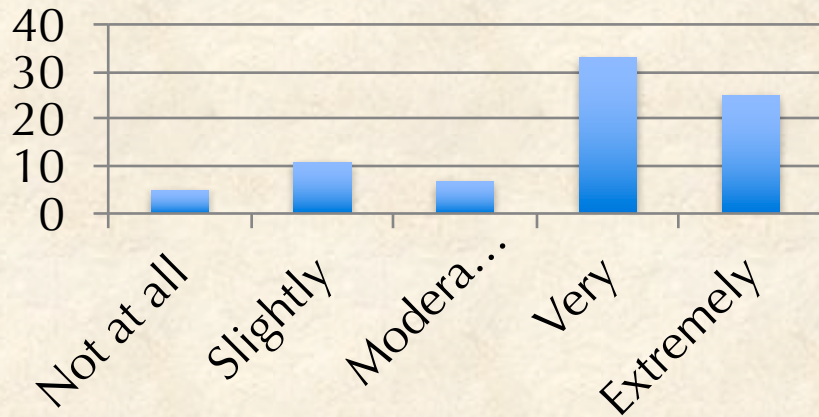


Hosted by Stepik



Text-Based Content

How valuable are the **lecture videos** in helping you learn?



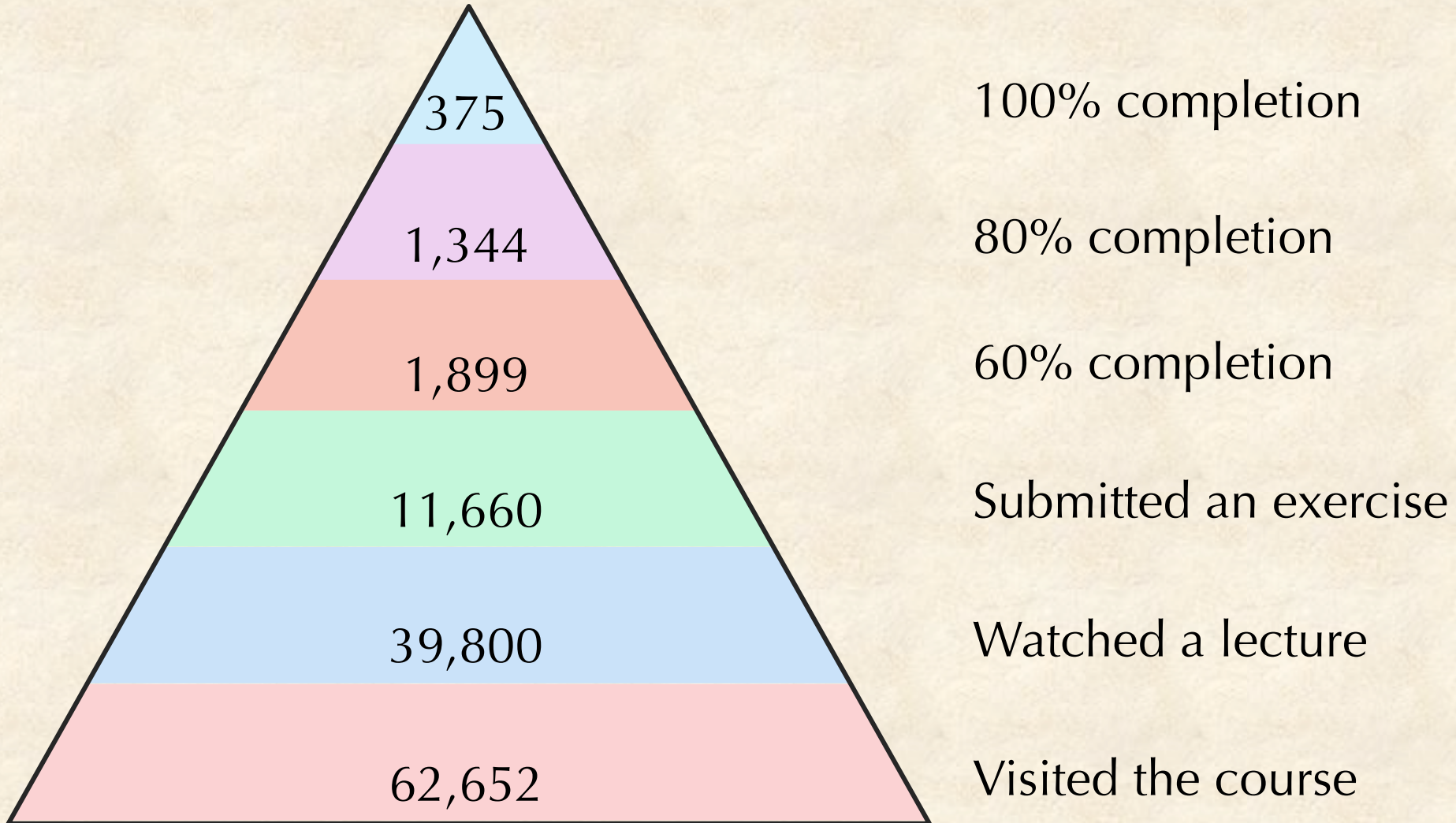
How valuable is the **interactive text** in helping you learn?



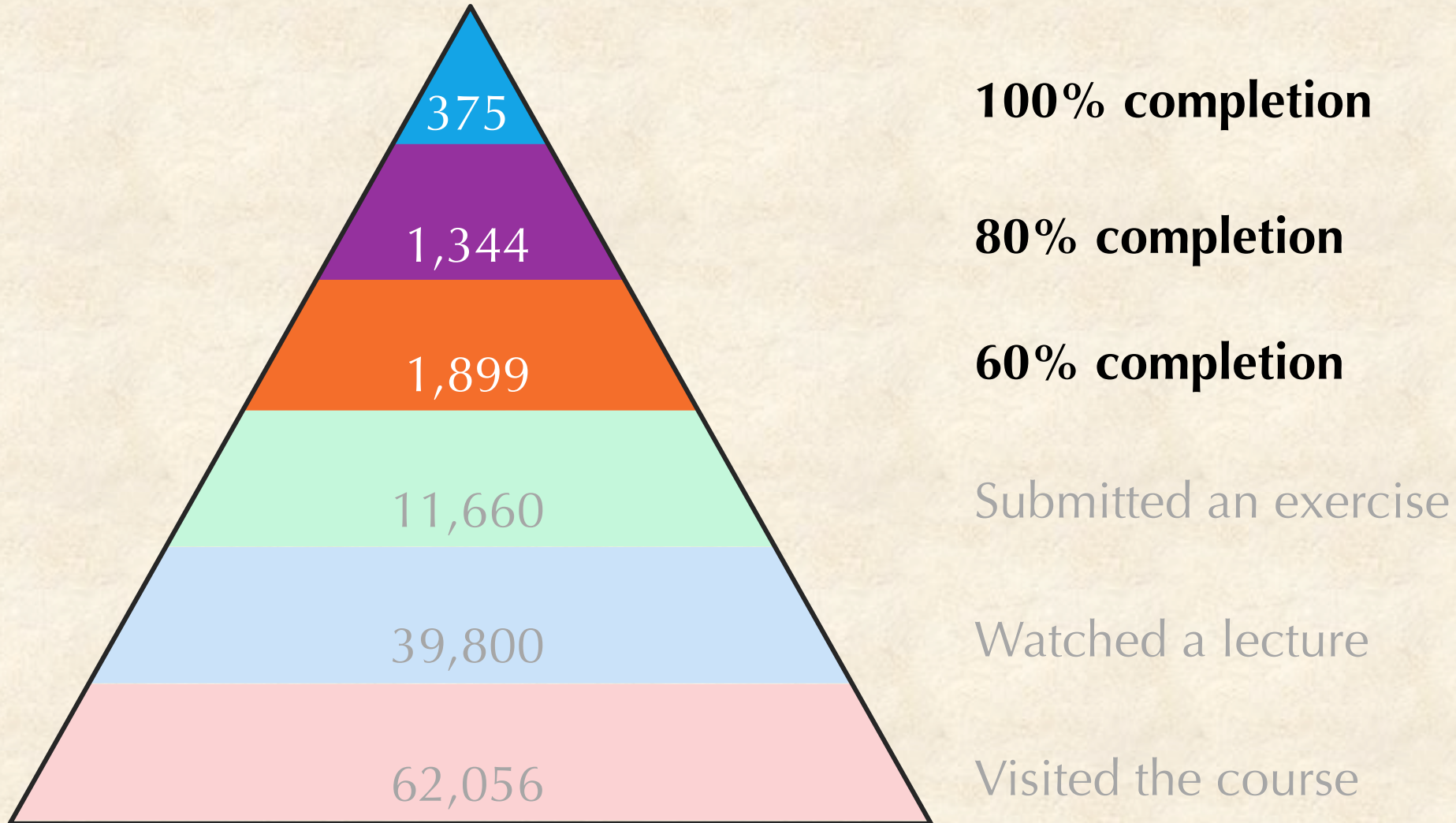
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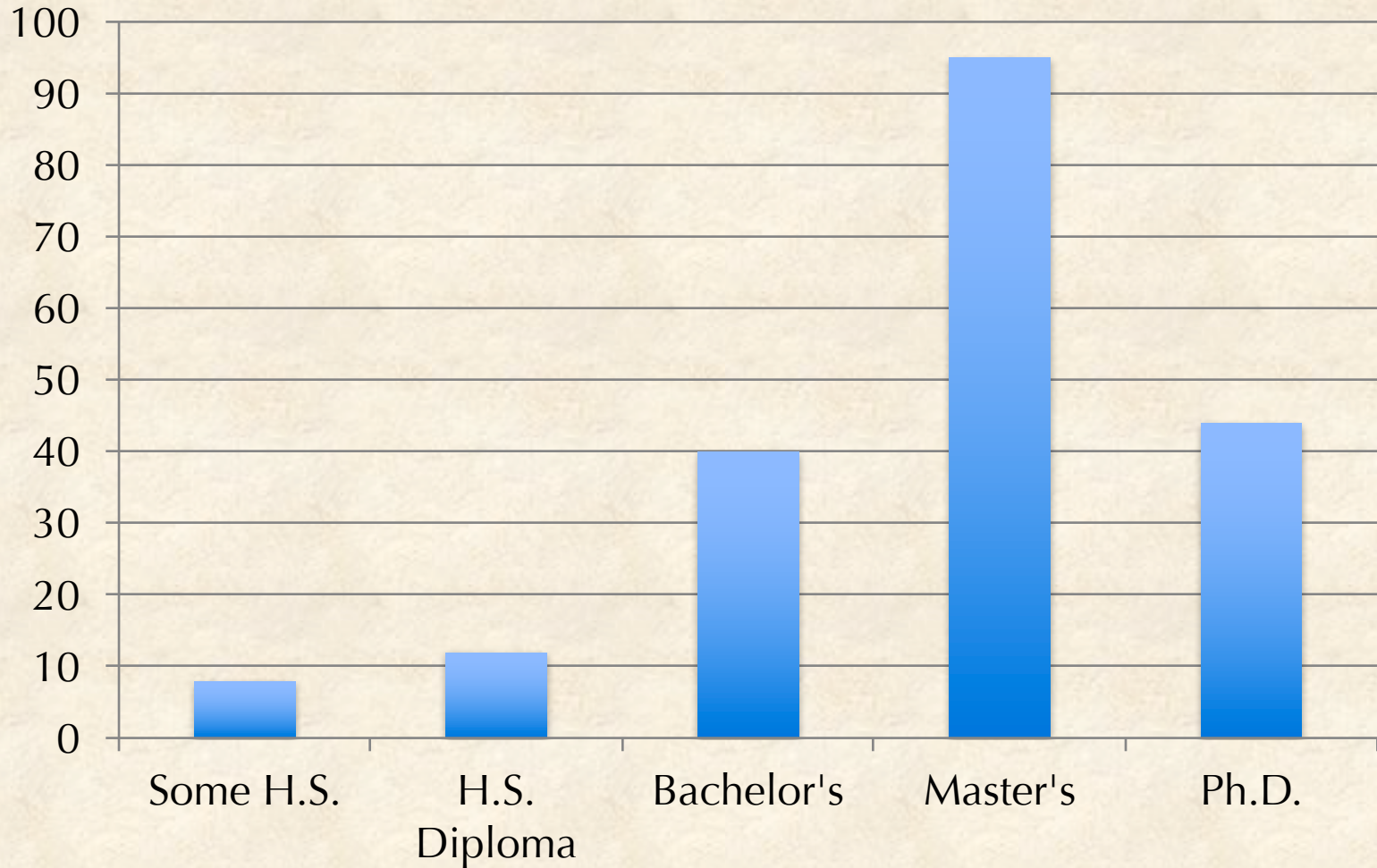
Student Stats (First Course, 2013-2015)



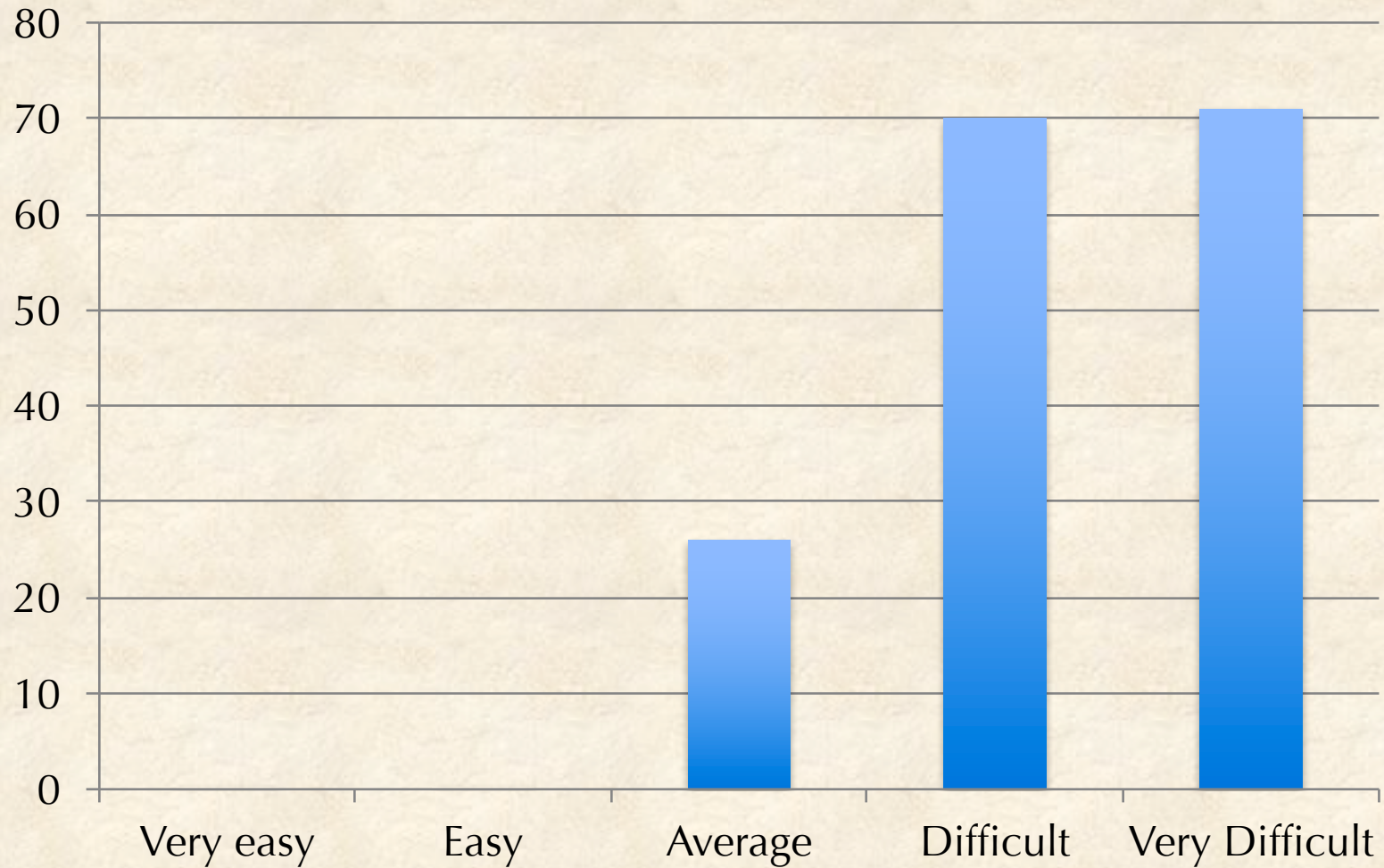
Student Stats (First Course, 2013-2015)



“Highest Educational Level Attained?”



“Relative Difficulty of Our MOOC?”



In Students' Words ...

HIGHEST RATED MOOC

This course is a *Top 50 MOOC of All Time* based on thousands of reviews written by Class Central users. It's guaranteed to be good!

Check out the rest of the [Top 50 here](#).

 **CLASS CENTRAL**

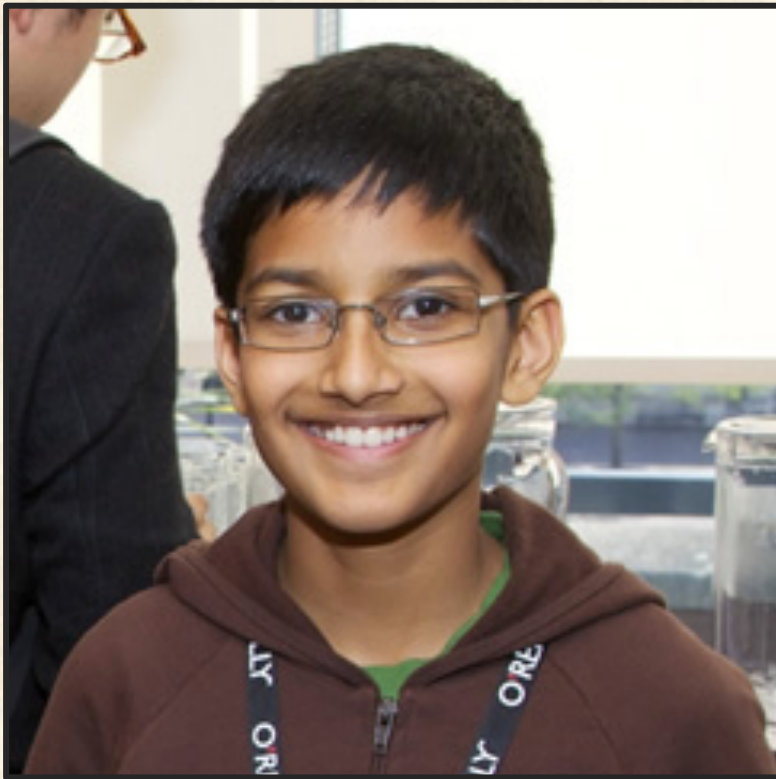
“This is, hands down, the best course I have ever taken.”

“MIT 7.00x, taught by Eric Lander, is the only [MOOC] that is on the same level. This is the highest compliment I can give.”



4.8 out of 5

Putting Faces to Names



Shadaj

"I got really excited about DNA when we learned about it in school..."

Putting Faces to Names



Holly

“This class has sparked a fire in me...”

Putting Faces to Names



Venkata

"I had a great genomics extension class once..."

Putting Faces to Names



Mark

“The new clone outperformed the original so we have destroyed the original ... there must have been a mutation.”

Putting Faces to Names



??????

“????? ??? ?????? ?? ??????
? ?????????????? ??? ? ??????”

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Building a Brand



Building a Brand



Generating Revenue

The screenshot shows the Coursera website for the Johns Hopkins University Data Science specialization. The header includes the Coursera logo and navigation links for Courses, Specializations, Institutions, About, and Phillip Comp... The main content area features the Johns Hopkins University logo, the title 'Data Science', and a description: 'A Sequence of Courses: Learn to be a Data Scientist and Apply Your Skills in a Capstone Project'. Below this, it mentions the 'Final Capstone Project created with:' followed by the SwiftKey logo. A navigation bar at the bottom of the main content area includes links for Overview, Certificate, Courses, Instructors, and FAQs, along with a prominent blue 'Start Specialization' button. The bottom section of the page is a light gray area with two columns of bullet points detailing the course and capstone project objectives.


coursera Courses Specializations Institutions About Phillip Comp... ▾

Johns Hopkins University

Data Science

A Sequence of Courses: Learn to be a Data Scientist and Apply Your Skills in a Capstone Project

Final Capstone Project created with:



Overview Certificate Courses Instructors FAQs [Start Specialization](#)

In this course you will learn:

- Formulate context-relevant questions and hypotheses to drive data scientific research
- Identify, obtain, and transform a data set to make it suitable for the production of statistical evidence communicated in written form
- Build models based on new data types, experimental design, and statistical inference

In this Capstone Project, you will:

- Build a predictive data model for analyzing large textual data sets
- Clean real-world data and perform complex regressions
- Create visualizations to communicate your data analyses
- Build a final data product in collaboration with SwiftKey, award-winning developer of leading keyboard apps for smartphones

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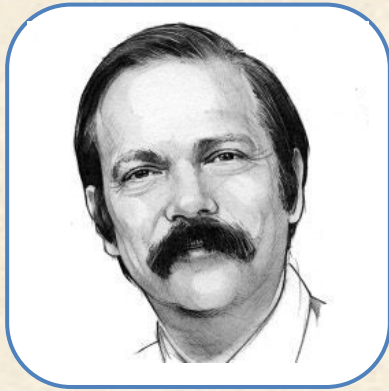
Forming Partners

- Industry partners
 - Course materials are currently used as a job interview tool at Illumina.
 - Adoption for continued education at biotech firms.
- University partners
 - Online courses will count as credit for candidates to MS program in Computer Science at UCSD.
 - Our MAIT is perfect for grad school bootcamps, which can be a pain for departments to implement.

What Exactly Are We Destroying?

COMMUNICATIONS
OF THE
ACM

Will MOOCs Destroy Academia?



Vardi, 2012

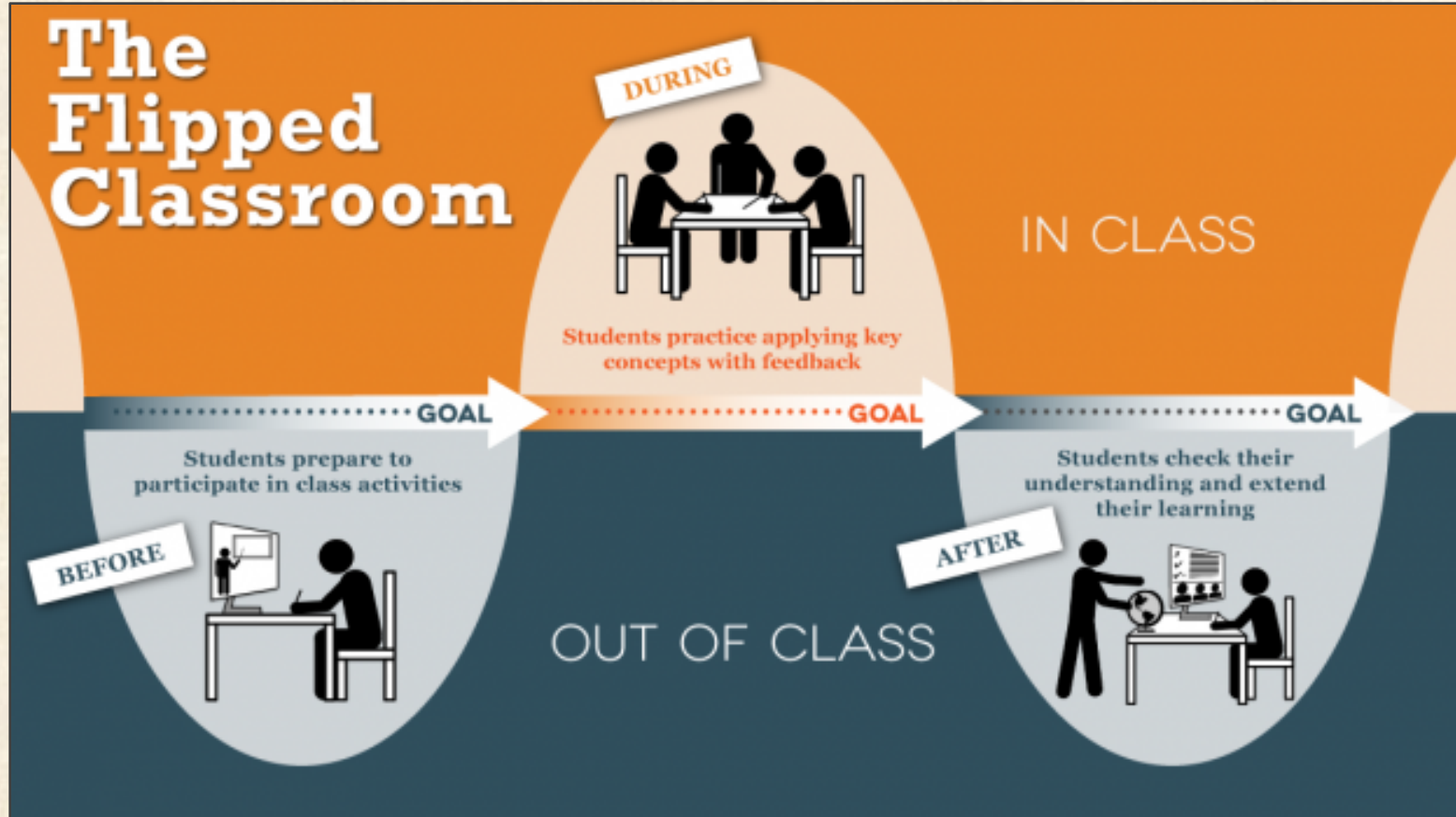
“If I had my wish, I would wave a wand and make MOOCs disappear.”

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Online Materials Inform Offline Courses

- At CMU, I teach a “flipped” class with 40 students divided into four discussion groups.

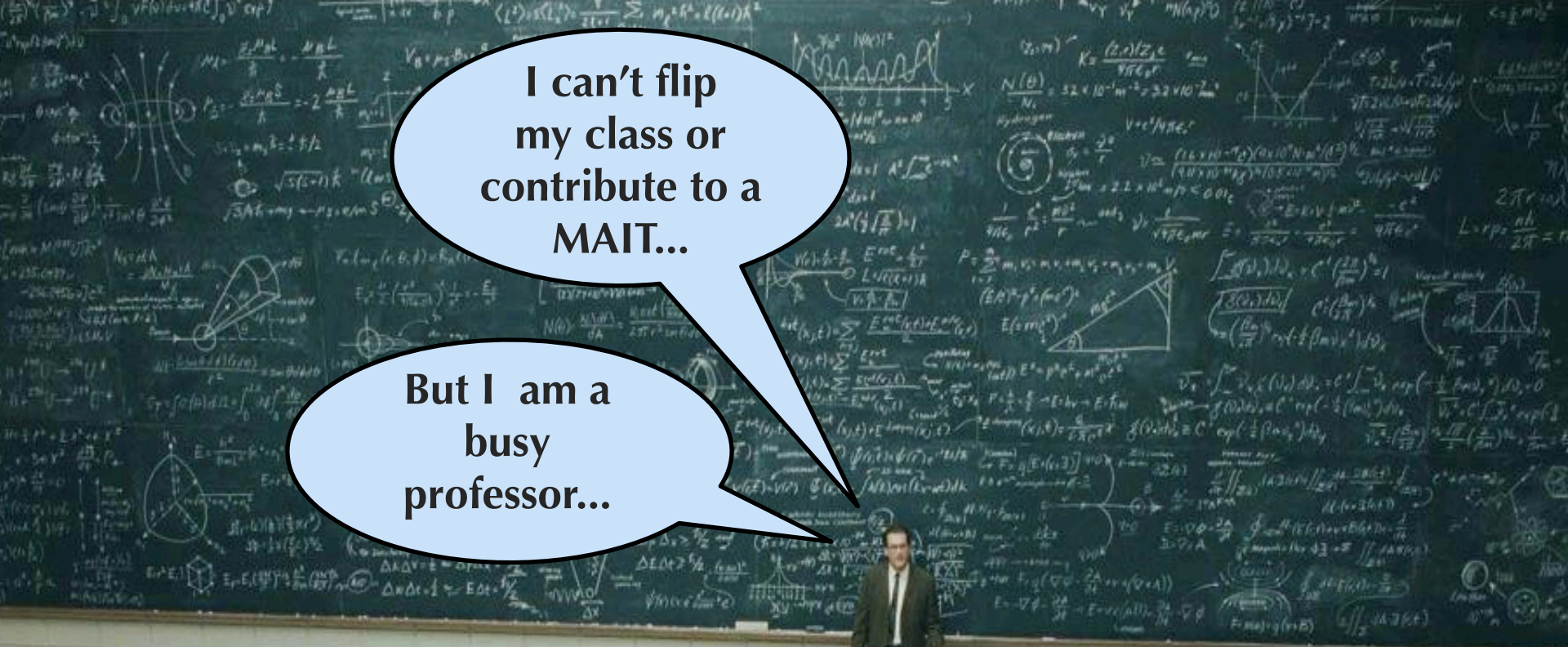






But I am a busy professor...





I can't flip my class or contribute to a MAIT...

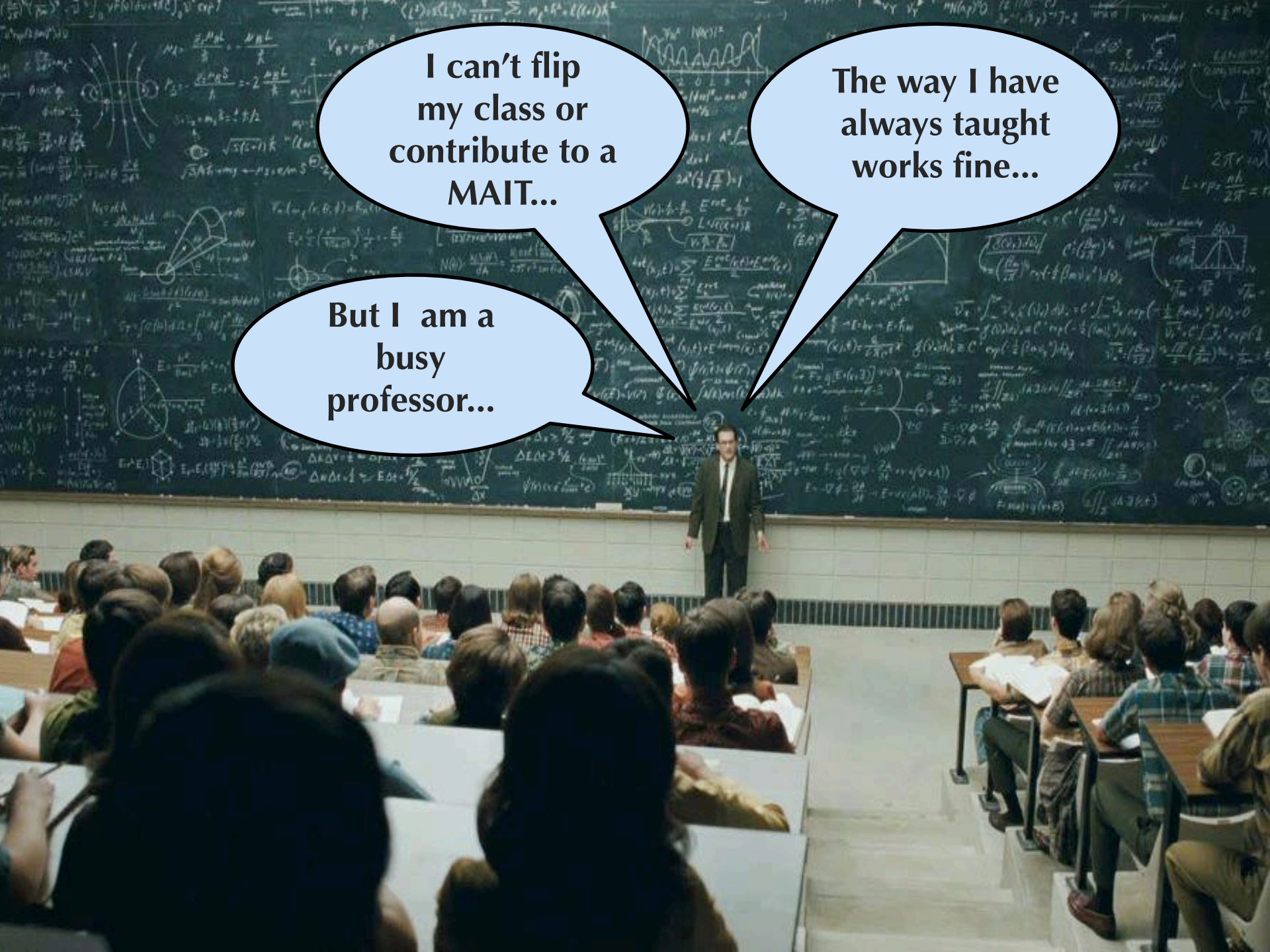
But I am a busy professor...



I can't flip
my class or
contribute to a
MAIT...

The way I have
always taught
works fine...

But I am a
busy
professor...

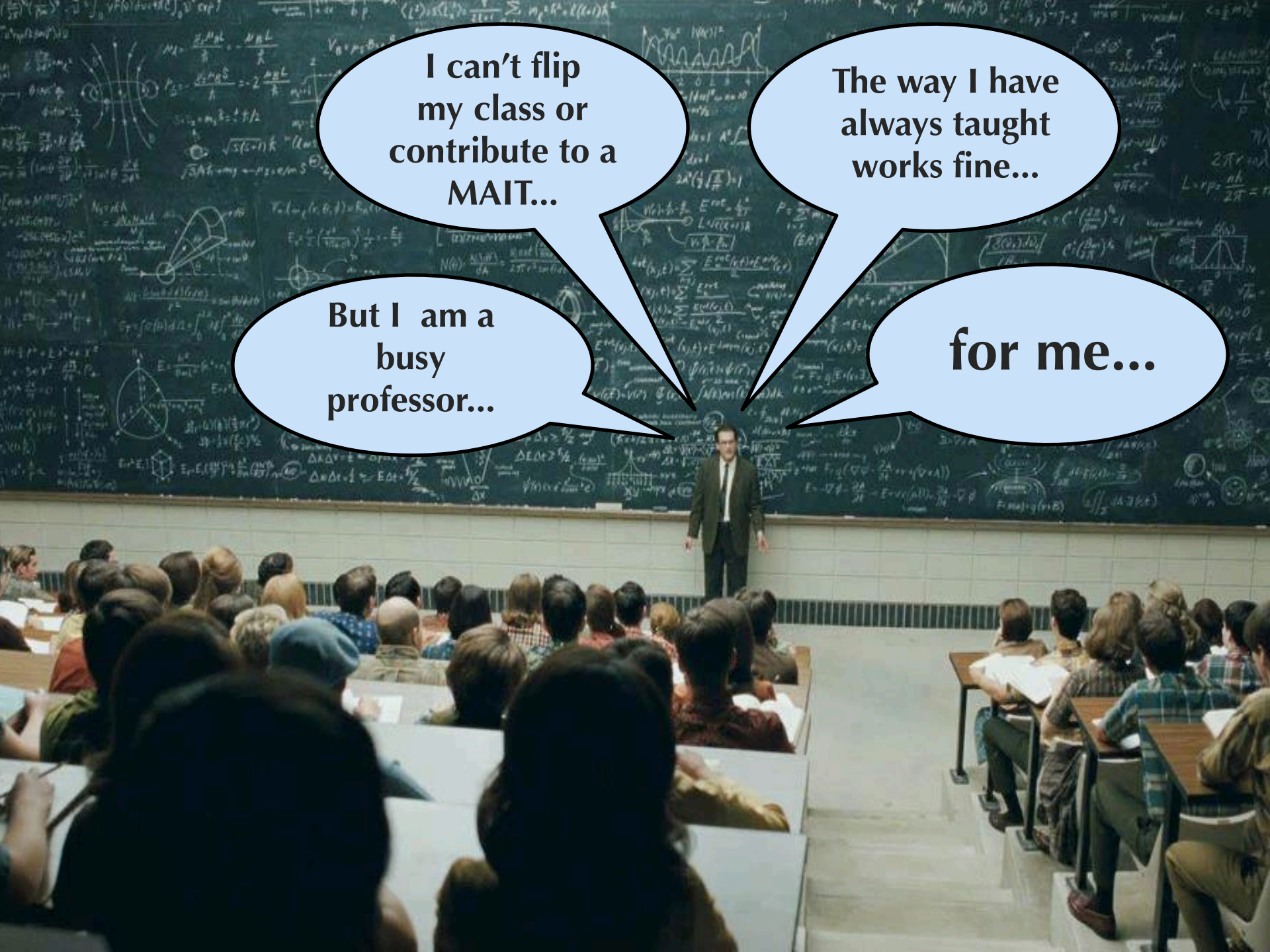


I can't flip
my class or
contribute to a
MAIT...

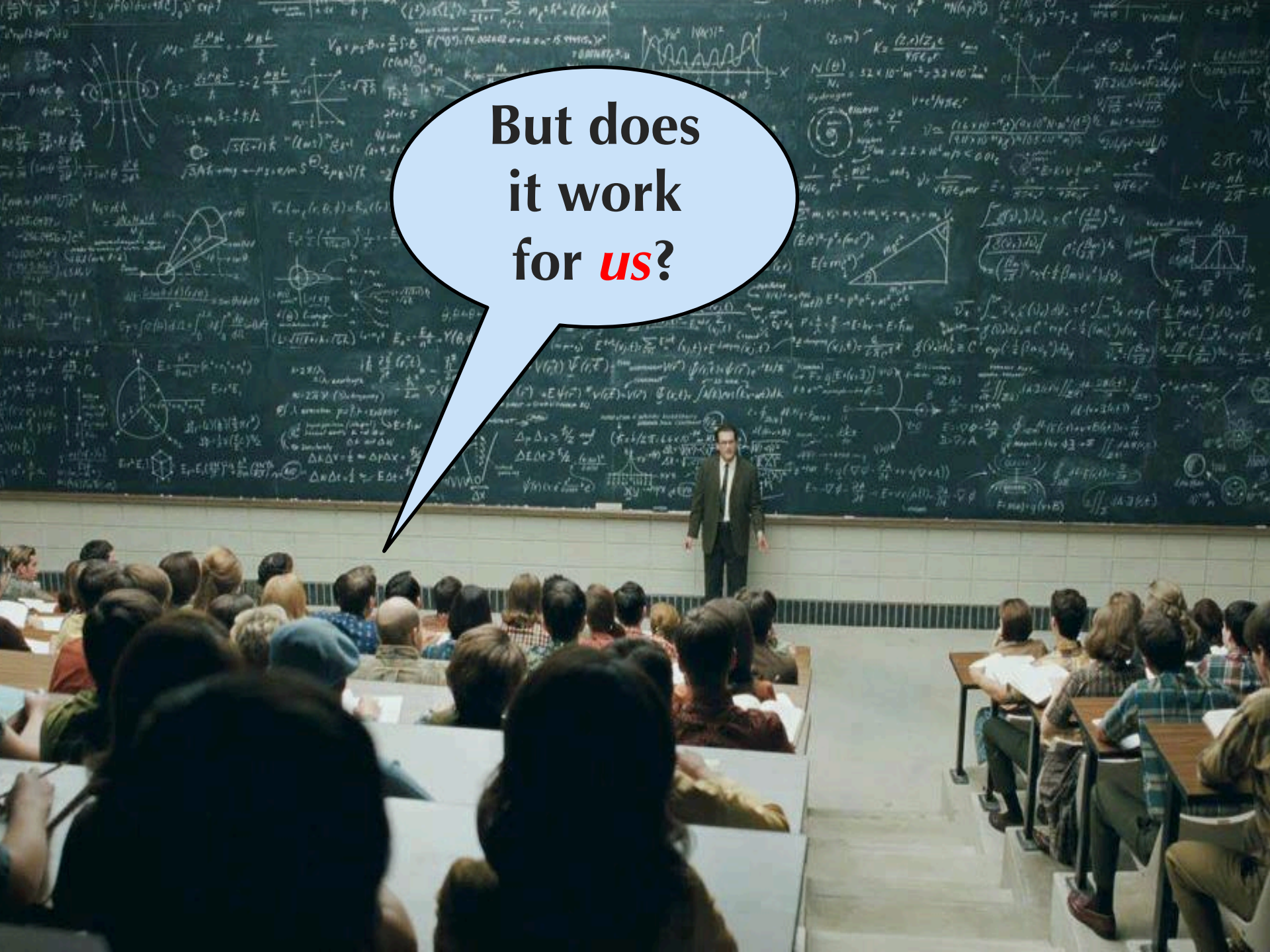
The way I have
always taught
works fine...

But I am a
busy
professor...

for me...



But does
it work
for *us*?



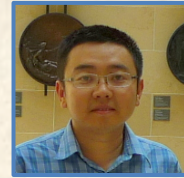
Acknowledgements



Nikolay Vyahhi
Rosalind founder,
Stepic CEO,
co-instructor



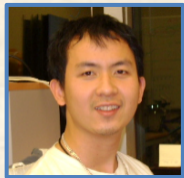
Olga Botvinnik
course/graphics
development



Yu Lin, Ph.D.
course
development



**Randy
Christopher**
resident artist



Son Pham, Ph.D.
invited lecturer,
course developer



Max Shen
course/software
development



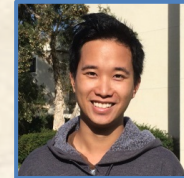
Robin Betz
course
development



Lars Bernstein
course
development



Kai Zhang
chief assessment
programmer



Vu Ngo
course/software
development



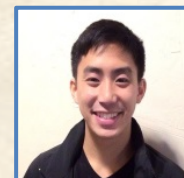
Mark Mammel
teaching asst,
content review



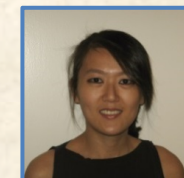
**Glenn Tesler,
Ph.D.**
content
review



Alexei Balandin
chief Rosalind
programmer



Jeffrey Yuan
course/software
development



Isabel Lupiani
teaching asst,
content review



Sangtae Kim
invited
lecturer

Acknowledgements



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