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?

1. Very negative
2. Somewhat negative
3. Ambivalent
4. Somewhat positive
5. Very positive
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!”
### Problems

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


Here's the list of Rosalind problems:

<table>
<thead>
<tr>
<th>ID</th>
<th>Title</th>
<th>Solved By</th>
<th>Correct ratio</th>
<th>Questions</th>
<th>Solutions</th>
</tr>
</thead>
<tbody>
<tr>
<td>DNA</td>
<td>Counting DNA Nucleotides</td>
<td>3644</td>
<td></td>
<td>1 day, 19 hours</td>
<td>3 hours, 21 minutes</td>
</tr>
<tr>
<td>RNA</td>
<td>Transcribing DNA into RNA</td>
<td>1912</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>REVC</td>
<td>Complementing a Strand of DNA</td>
<td>2025</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GC</td>
<td>Computing GC Content</td>
<td>1606</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HAMM</td>
<td>Counting Point Mutations</td>
<td>2188</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SUBS</td>
<td>Finding a Motif in DNA</td>
<td>1821</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GRPH</td>
<td>Overlap Graphs</td>
<td>768</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IPRB</td>
<td>Mendel's First Law</td>
<td>201</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LCS</td>
<td>Finding a Shared Motif</td>
<td>581</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MPRT</td>
<td>Finding a Protein Motif</td>
<td>100</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>PERM</td>
<td>Enumerating Gene Orders</td>
<td>1266</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PROTC</td>
<td>Protein Translation</td>
<td>1461</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>REVP</td>
<td>Locating Restriction Sites</td>
<td>592</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IEV</td>
<td>Calculating Expected Offspring</td>
<td>118</td>
<td></td>
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<tr>
<td>LEXF</td>
<td>Enumerating k-mers Lexicographically</td>
<td>588</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>LIA</td>
<td>Independent Alleles</td>
<td>45</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
• 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
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• 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

**The New York Times**
5/2013

**Slate**
7/2013

**THE CHRONICLE of Higher Education**
7/2013

**Will MOOCs Destroy Academia?**

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

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

**A MOOC Delusion:**
Why Visions to Educate the World are Absurd
Criticisms of MOOCs

Will MOOCs Destroy Academia?

Vardi, 2012

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

Will MOOCs Destroy Academia?

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“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
Hoarding Class

200+ students to 1 instructor
Learning Breakdown
Bloom’s $2\sigma$ Problem (1984)
Massive Adaptive Interactive Text

Massive Open Online Course
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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

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

Max Shen
course/software development

Robin Betz
course development

Kai Zhang
chief assessment programmer

Vu Ngo
course/software development

Mark Mammel
teaching asst, content review

Alexei Balandin
chief Rosalind programmer

Jeffrey Yuan
course/software development

Isabel Lupiani
teaching asst, content review

Randy Christopher
resident artist

Lars Bernstein
course development

Glenn Tesler, Ph.D.
content review

Sangtae Kim
invited lecturer
Massive Development Resources

HHMI
HOWARD HUGHES MEDICAL INSTITUTE
2013-2014

MINISTRY OБРАЗОВАНИЯ И НАУКИ РОССИЙСКОЙ ФЕДЕРАЦИИ
2013-2014

THE UNIVERSITY OF CALIFORNIA
1868
2014-2015

NIH
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 $2\sigma$ improvement?
From Active to **Adaptive** Learning
From Active to **Adaptive** Learning
From Active to **Adaptive** Learning
From Active to **Adaptive** Learning

Learning Breakdown
From Active to Adaptive Learning
From Active to Adaptive Learning

Learning Breakdown
From Active to **Adaptive** Learning

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Core Material

Remedial Modules
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  CTCA  GTCGACCTTTACTC
```

- 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 Interactive 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
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)

- Visited the course: 62,652
- Watched a lecture: 375
- Submitted an exercise: 1,344
- 60% completion: 1,899
- 80% completion: 11,660
- 100% completion: 39,800

100% completion
80% completion
60% completion
Submitted an exercise
Watched a lecture
Visited the course
Student Stats (First Course, 2013-2015)

62,056

375

1,344

1,899

11,660

39,800

62,056

100% completion

80% completion

60% completion

Submitted an exercise

Watched a lecture

Visited the course
“Highest Educational Level Attained?”

- Some H.S.
- H.S. Diploma
- Bachelor's
- Master's
- Ph.D.
“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.*

“*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

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:

SwiftKey.

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?

Will MOOCs Destroy Academia?

Vardi, 2012

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Online Materials Inform Offline Courses

• At CMU, I teach a “flipped” class with 40 students divided into four discussion groups.
Life After Massive Open Online Courses (MOOCs):

Online Science Education Needs a New Revolution

Pavel Pevzner
Department of Computer Science and Engineering
University of California at San Diego

But I am a busy professor...
Life After Massive Open Online Courses (MOOCs):

Online Science Education Needs a New Revolution

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But I am a busy professor...

I can’t flip my class or contribute to a MAIT...
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But I am a busy professor...

The way I have always taught works fine...
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for me...
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But does it work for us?
Acknowledgements

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course/graphics development

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course development

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