Innovations in Higher Education

generated by four revolutions!

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Former Dean of Engineering
Rice University, Connexions, and OpenStax
June 2014

Innovations in Education from a convergence of four revolutions

- A new type of open text book has emerged
- A new type of open course has emerged
- A new personalized learning environment is emerging: Interactive, adaptive, assessing
- A new type of certification is being developed

The Convergence in Education

- A strong reaction from society, parents, and students to the rising cost of education
- A general agreement that there is a need for greater access to education and universal access to knowledge
- All countries need a trained workforce and an informed general population that only comes through education. Second to poverty, lack of education is the most destructive element in a democratic society

Disruptive Technologies

Disruptive technologies change the world in **two phases**:

1. The new technology **first** does what the old technology did, only better. It solves the existing problem. Results are often "Intended Consequences"

2. The new technology **then** redefines the problem, asks new questions that were not possible in the first phase. Where **surprising innovation** is observed. Results often "Unintended Consequences"

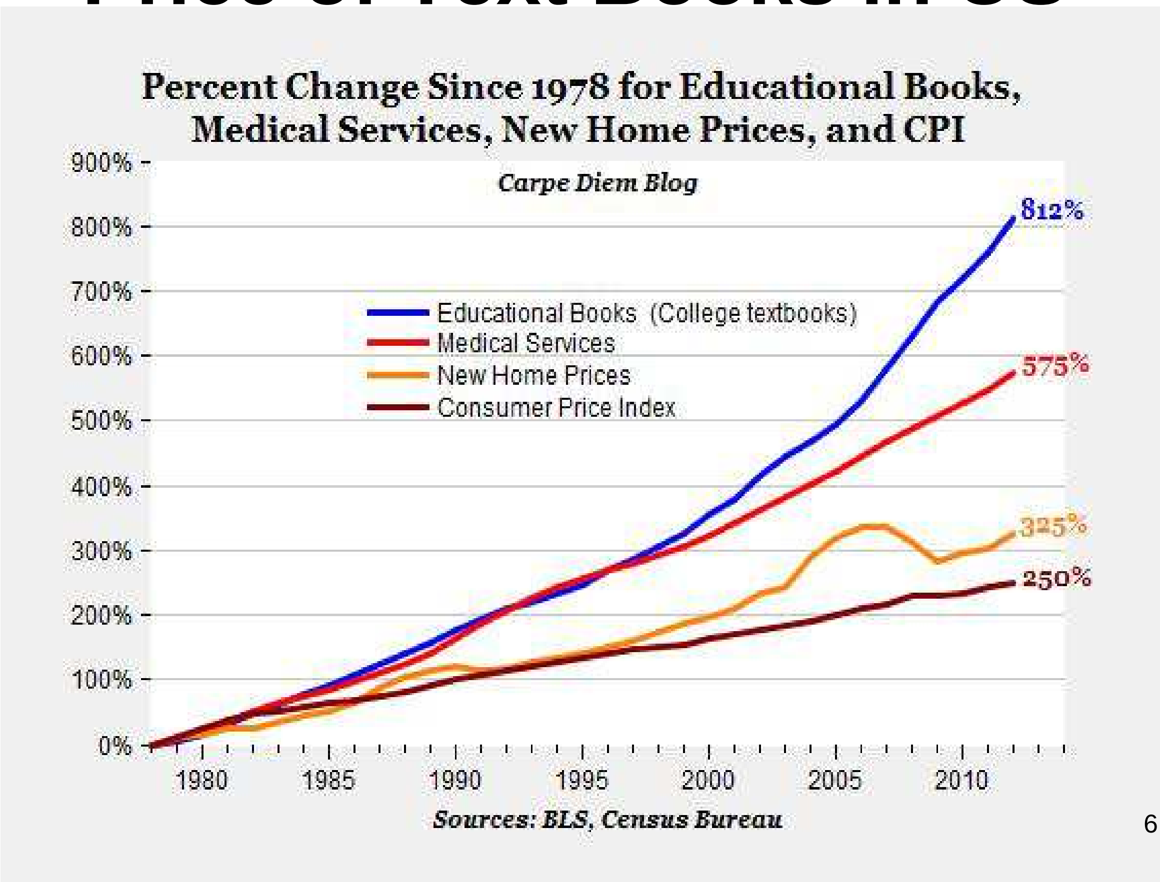
The Traditional Book

The book is the central tool or technology in education at all levels, for all aspects.

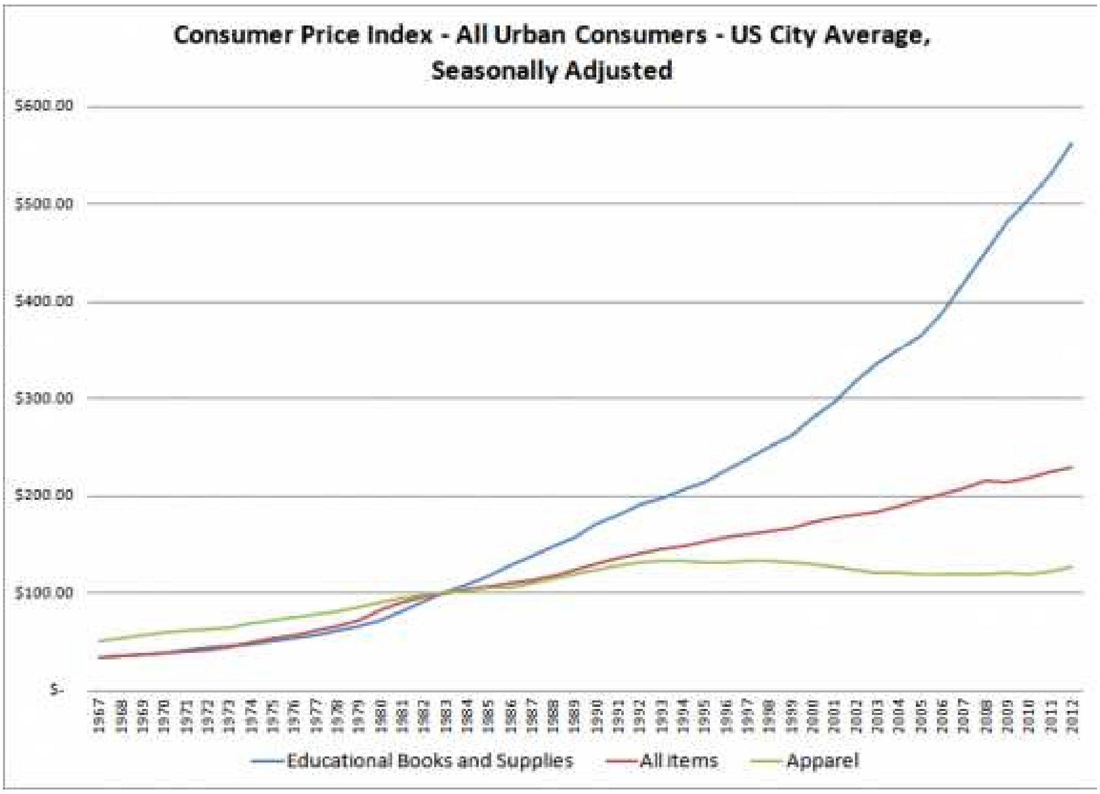
The book is a **mature technology** that is not improving. It and the supporting infrastructure are the answer to the educational questions of the 19th century.

Books are now the "bottle neck" or "barrier". They are no longer the answer, they are the problem

Price of Text Books in US



Price of Text Books in US

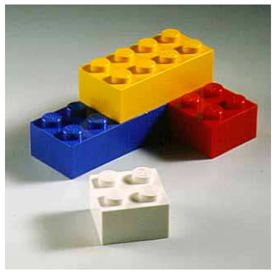


Open Educational Resources

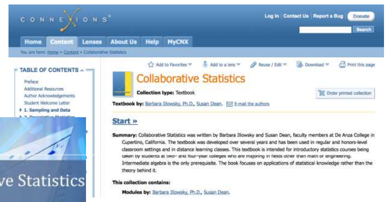
Borrowing from the success of the Open Source Software movement, **OER**s are:

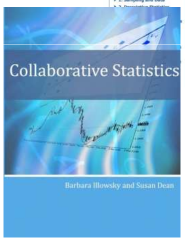
- **Open** to any student, teacher, or author worldwide
- **Licensed** under the **Creative Commons** copyright to maximize use and reuse
- **Modular** in structure for reuse and remixing
- Implemented in a **semantic language** such as XML or HTML5+ which uses metadata
- Made available over the **Web**

CONNEXIONS
CNX.ORG

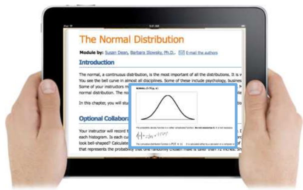


digital open publishing platform
founded at Rice University in 1999
now named **OpenStax Cnx**





1400 open textbooks/collections
22,000 educational Lego blocks
40 languages



>1 million users per month
from 190 countries

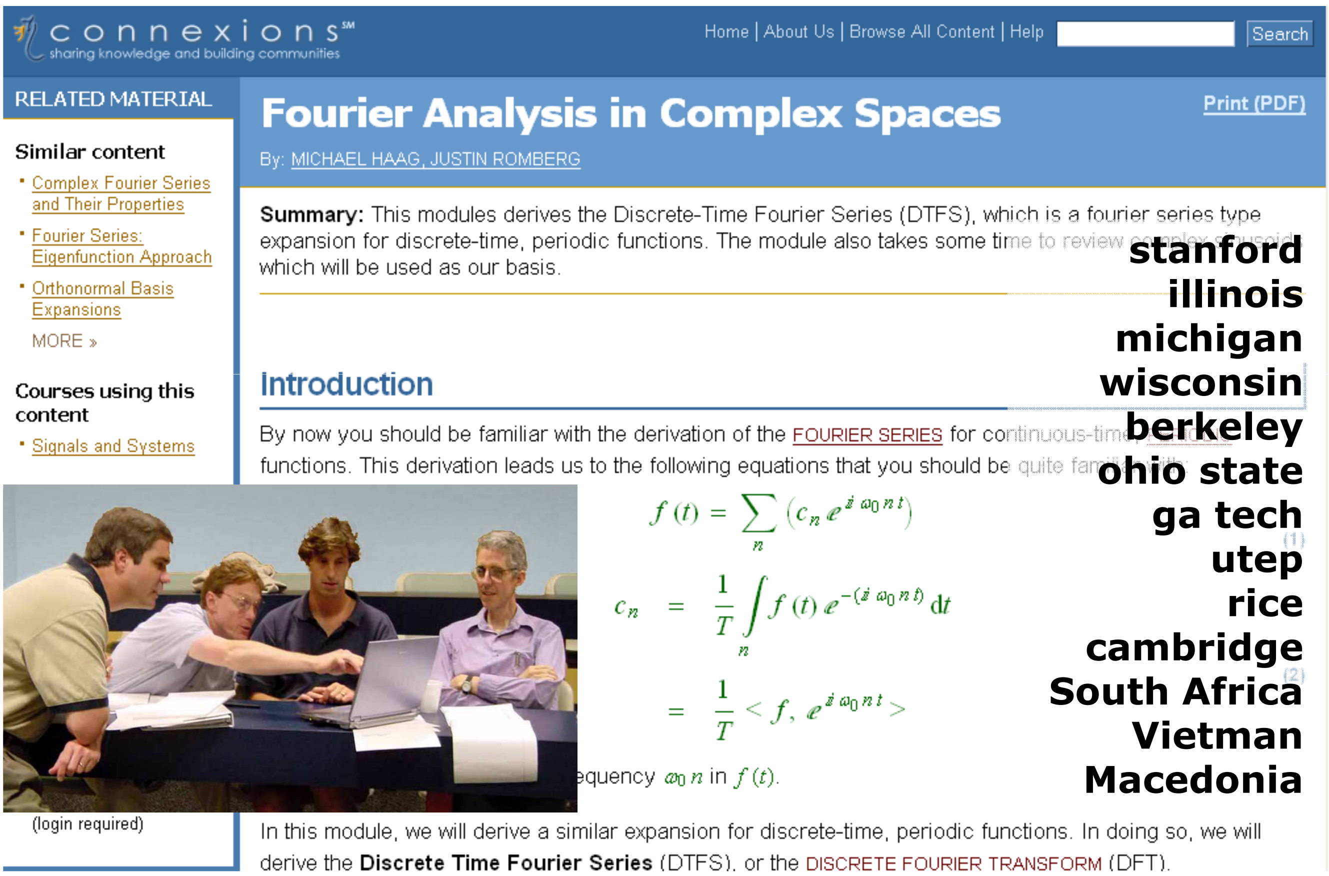
STEM content used
100 million times since 2007

Google

THE WILLIAM AND FLORA HEWLETT FOUNDATION

OPEN SOCIETY FOUNDATIONS

Create, Author



stanford
illinois
michigan
wisconsin
berkeley
ohio state
ga tech
utep
rice
cambridge
South Africa
Vietman
Macedonia

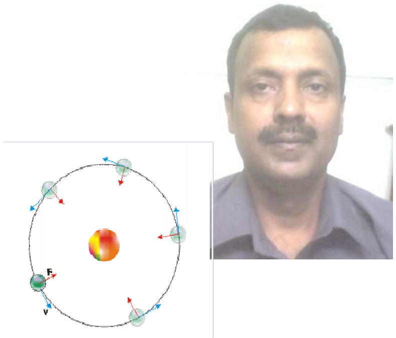
~~un~~expected consequences

Catherine Schmidt-Jones

private music teacher, USA

music theory textbooks

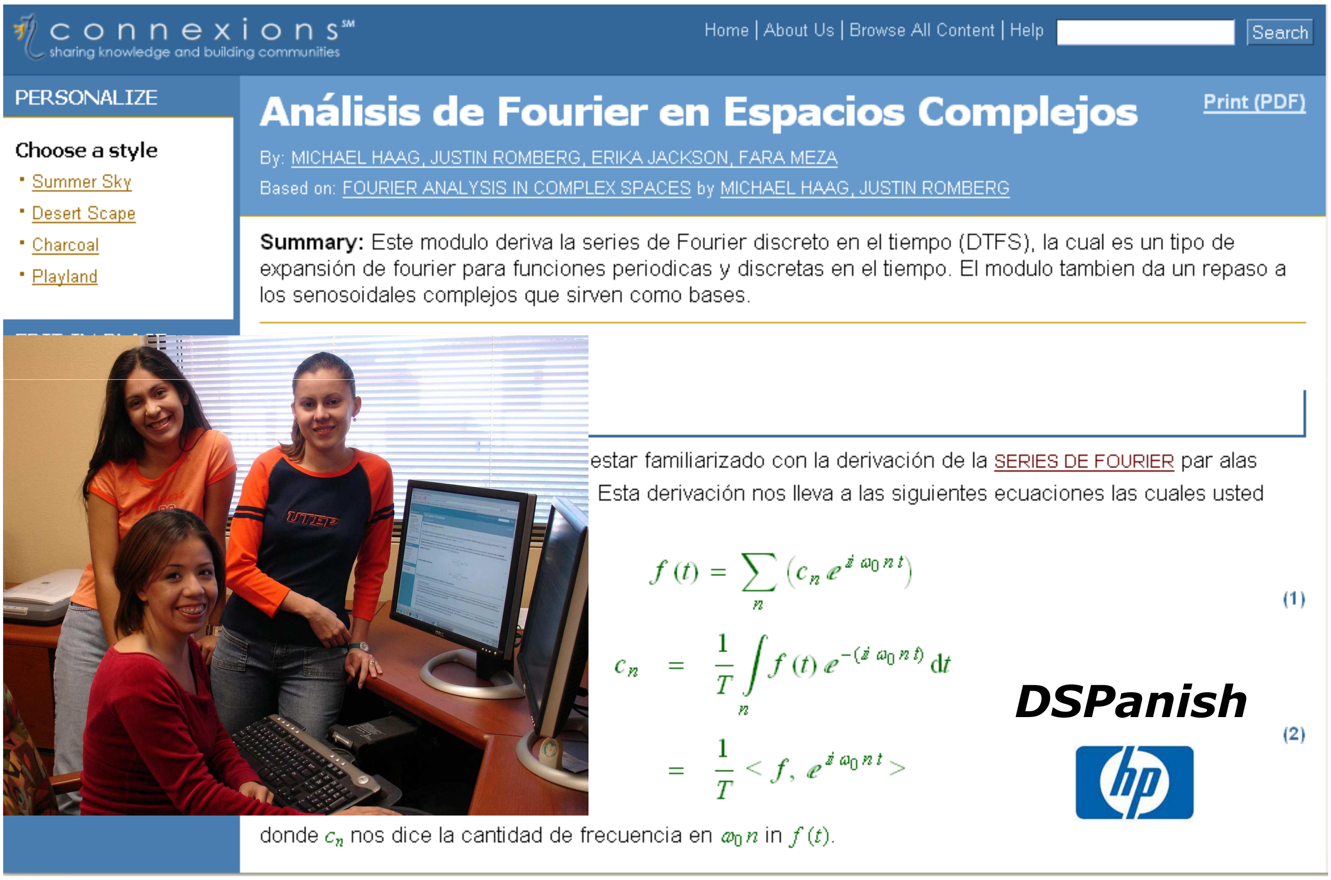
Sunil Kumar Singh



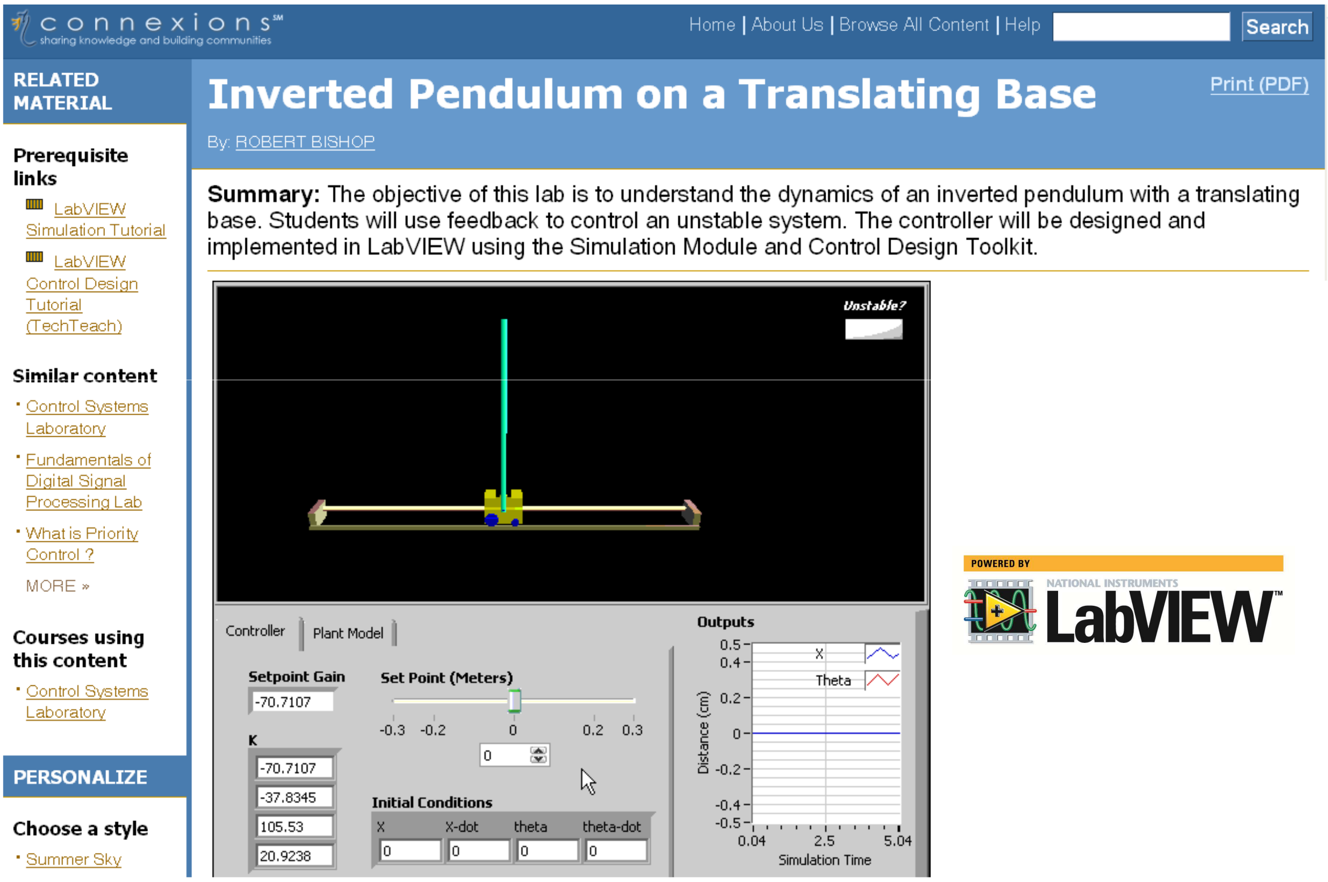
engineer and parent, India

physics textbook

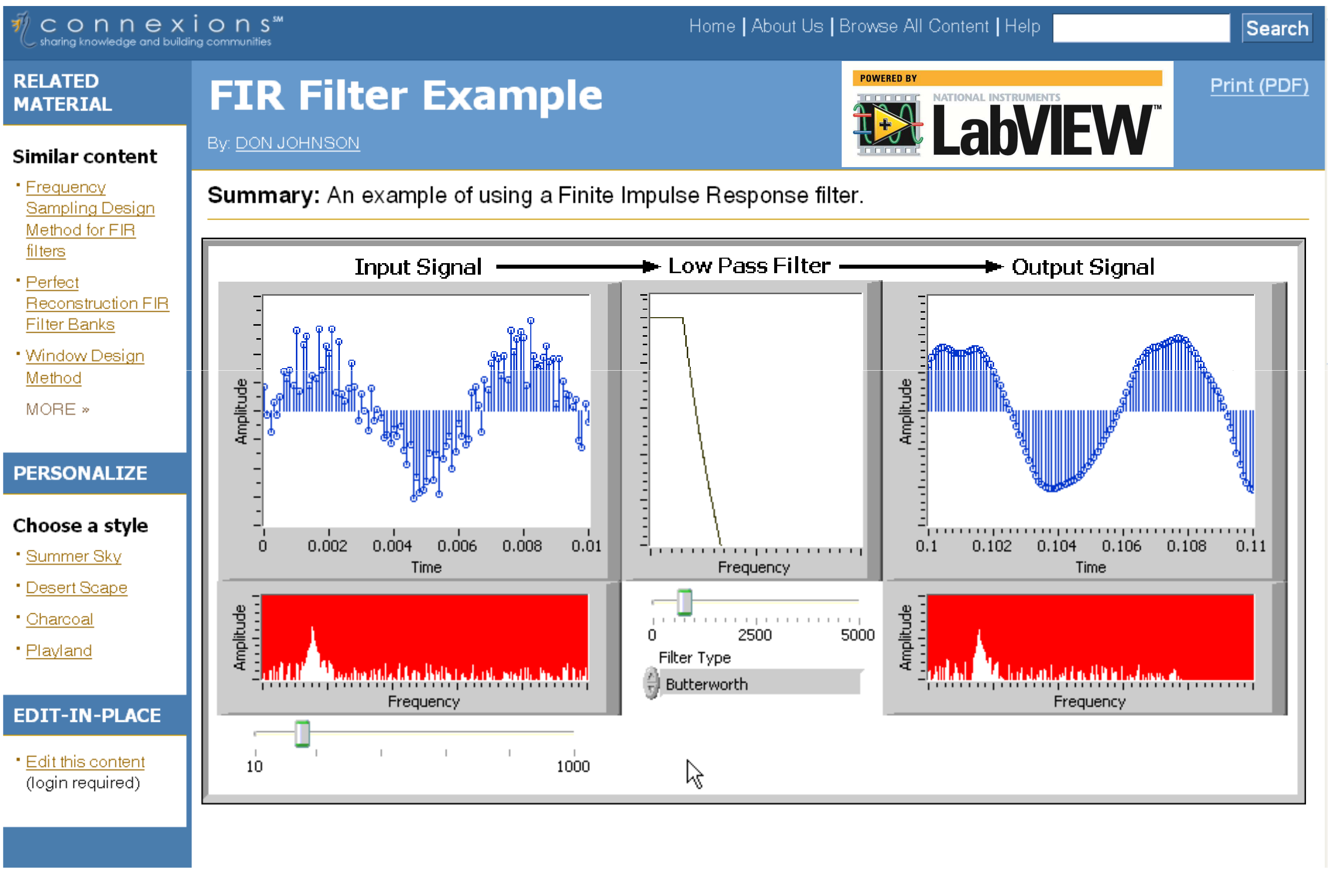
Connexions in Spanish



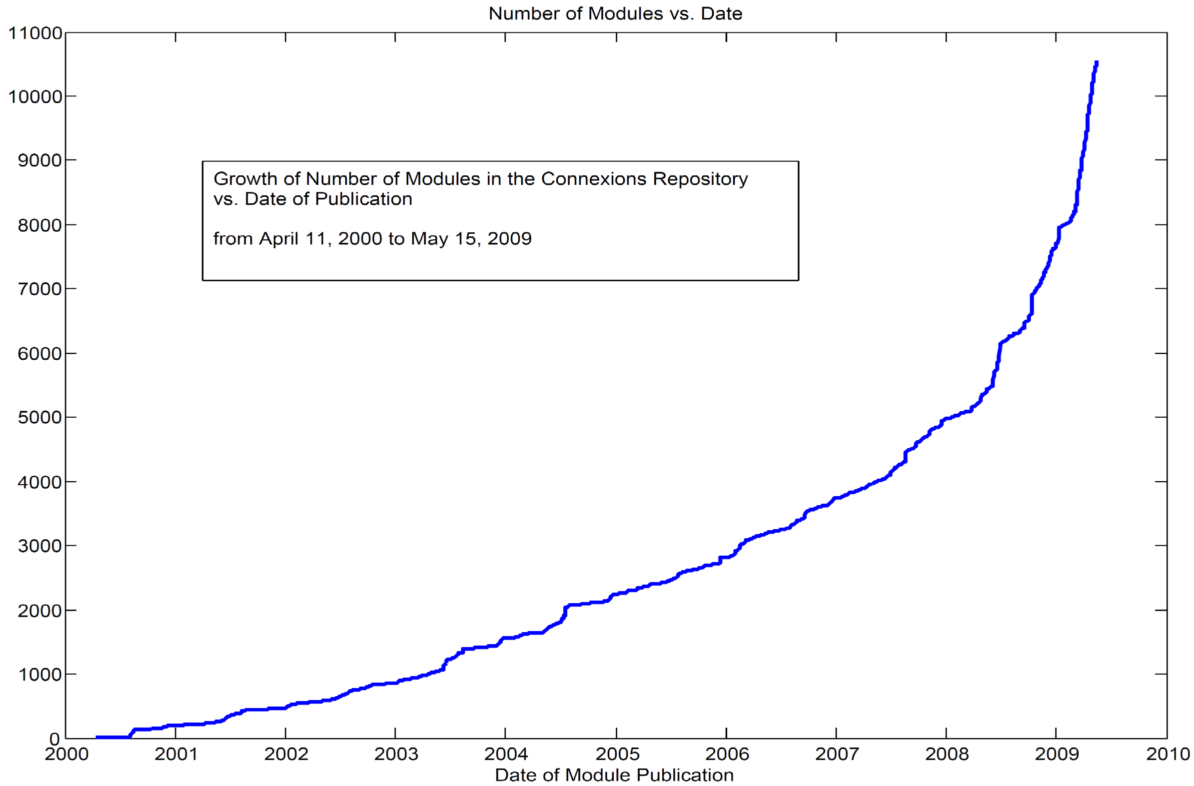
Interactive, Dynamic Virtual Lab



Virtual Laboratory



Growth of Numbers of Modules



Rice's OpenStax College

- Founded in 2010 by Richard Baraniuk
- Goal is to produce low-cost (perhaps free), high quality, up-to-date textbooks
- Is built on top of **Connexions**
- 25 Community College and University level books are planned for the most popular courses
- Two (Physics and Sociology) are finished and have been adopted by 30 courses and used at over 100 colleges in the US
- Anatomy and Biology came out April 2013, Statistics in 2014

progress to date

openstax COLLEGE

484 adoptions
70k students
$7.1M saved

UMass Amherst
U Oklahoma
U Georgia
UT Austin
UC Irvine
Tacoma CC
Anna Arundel CC
Dalhousie University
Central Florida State
Massachusetts Bay CC
...

3.5M unique web users

500K full text downloads

phase 1
(published)

phase 2
(2013/15)

US partners drive scaling and sustainability

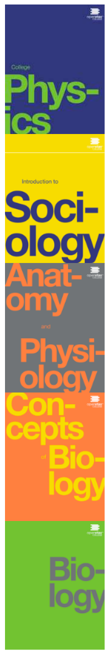
openstax COLLEGE

sapling learning
Apple
WILEY Publishers Since 1807
WebAssign
MICHIGAN
EXPERT ta theexpertTA.com
simbio
VERITAS TUTORS
COURSELOAD
Learningpod™
Google
lumen

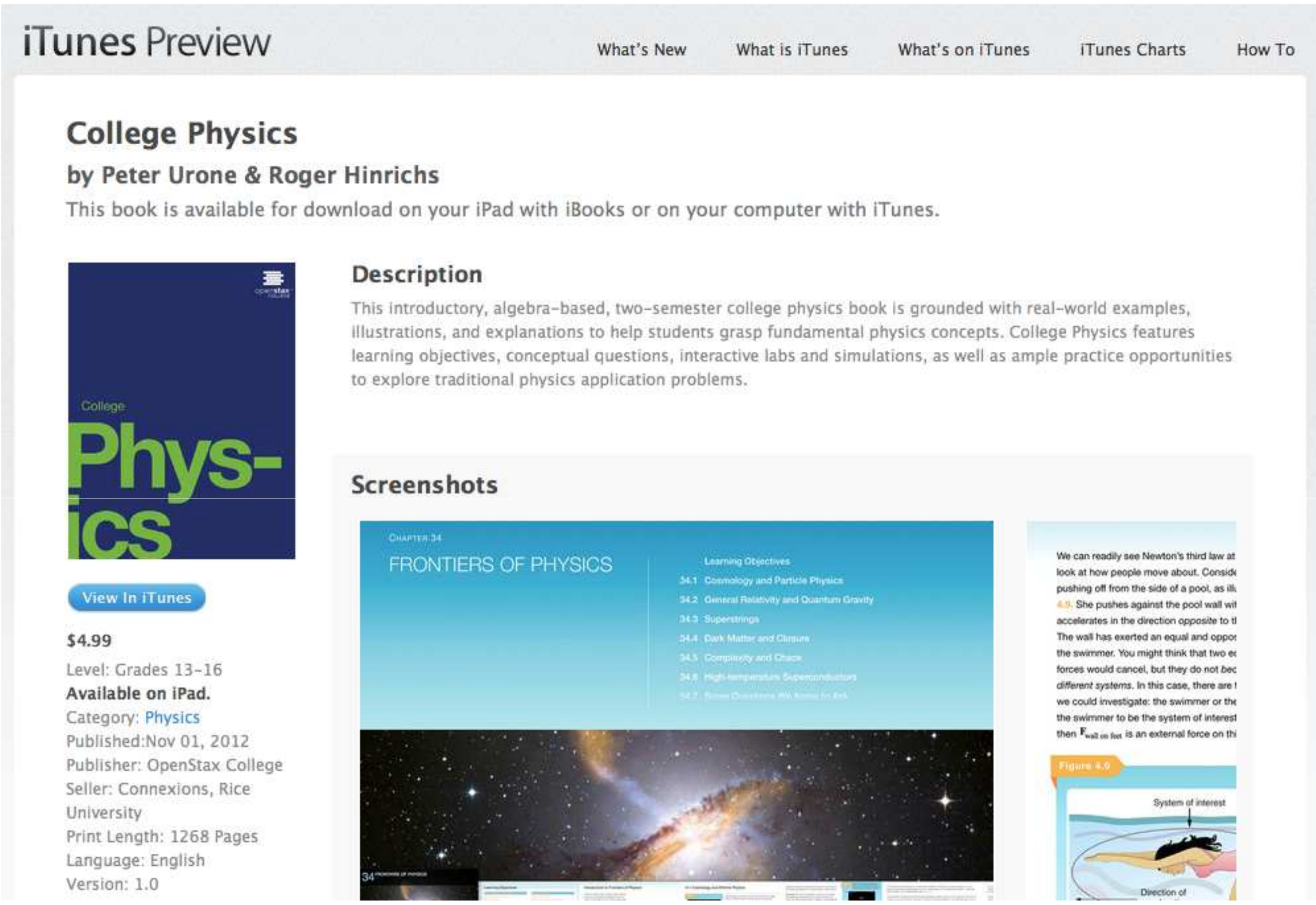
Open College Textbooks

openstax COLLEGE

- **high quality** – editorial board of Nobelists, former directors of US NSF
- **turn-key solutions,** adoptable (also adaptable!)
- at 10% market share (US), each year will save 1.6M students $160M per year (**10x ROI/year**)
- 105 adoptions, 10000 students, $1M+ in savings already in Fall 2012
- sustaining ecosystem of **corporate partners**
- positive **disruption**
- library of **25 free college texts**

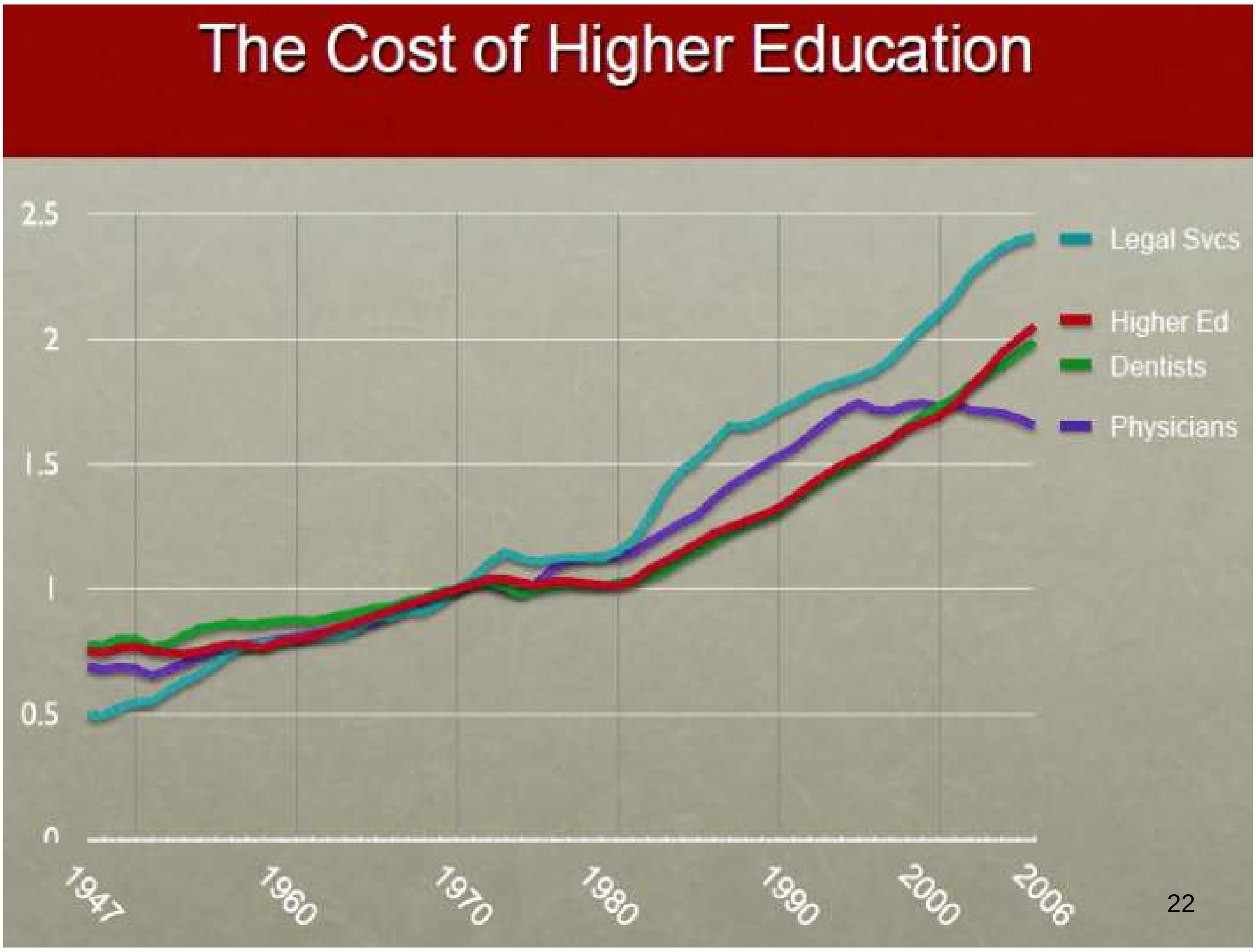


THE WILLIAM AND FLORA HEWLETT FOUNDATION · BILL & MELINDA GATES foundation · 20MM TWENTY MILLION MINDS FOUNDATION · MAXFIELD FOUNDATION



Massive Open Online Courses: MOOCs

- **Massive:** Enrollments of tens or hundreds of thousand students
- **Open:** Any person may register for the MOOC, no admission requirements or fees
- **Online:** Available over the Internet, probably under a browser
- **Course:** Looks like a traditional course, or perhaps more like an advanced book (i.e. an educational resource (an OER)). Phase 2?



The Traditional Lecture

The lecture is a central tool or technology in much of education.

The lecture is a **mature technology** that is not significantly improving. It was the answer to the educational questions of the 18th and 19th century.

They are now the “bottle neck” or “barrier”. They are no longer the answer, they are the problem

The MOOCs started at Stanford

The MOOC was created to solve the access problem.

From Stanford courses came Coursera and Udacity. From MIT and Harvard came edX.

These are very interesting examples of phase one innovation.

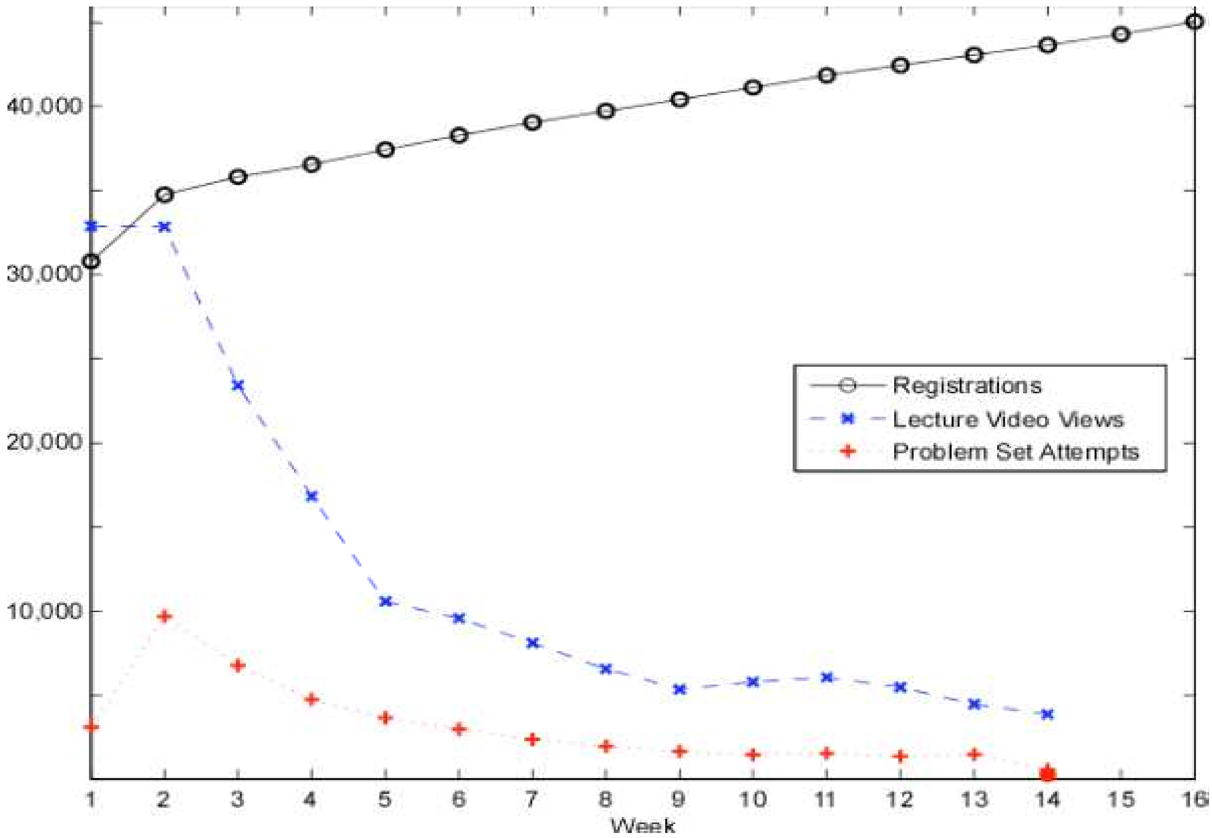
6.002 from MIT over edX

- 150,000 students registered
- 26,000 did the first problem set
- 10,000 did the first exam
- 9,000 did the next assignment
- 7,000 “completed” the MOOC

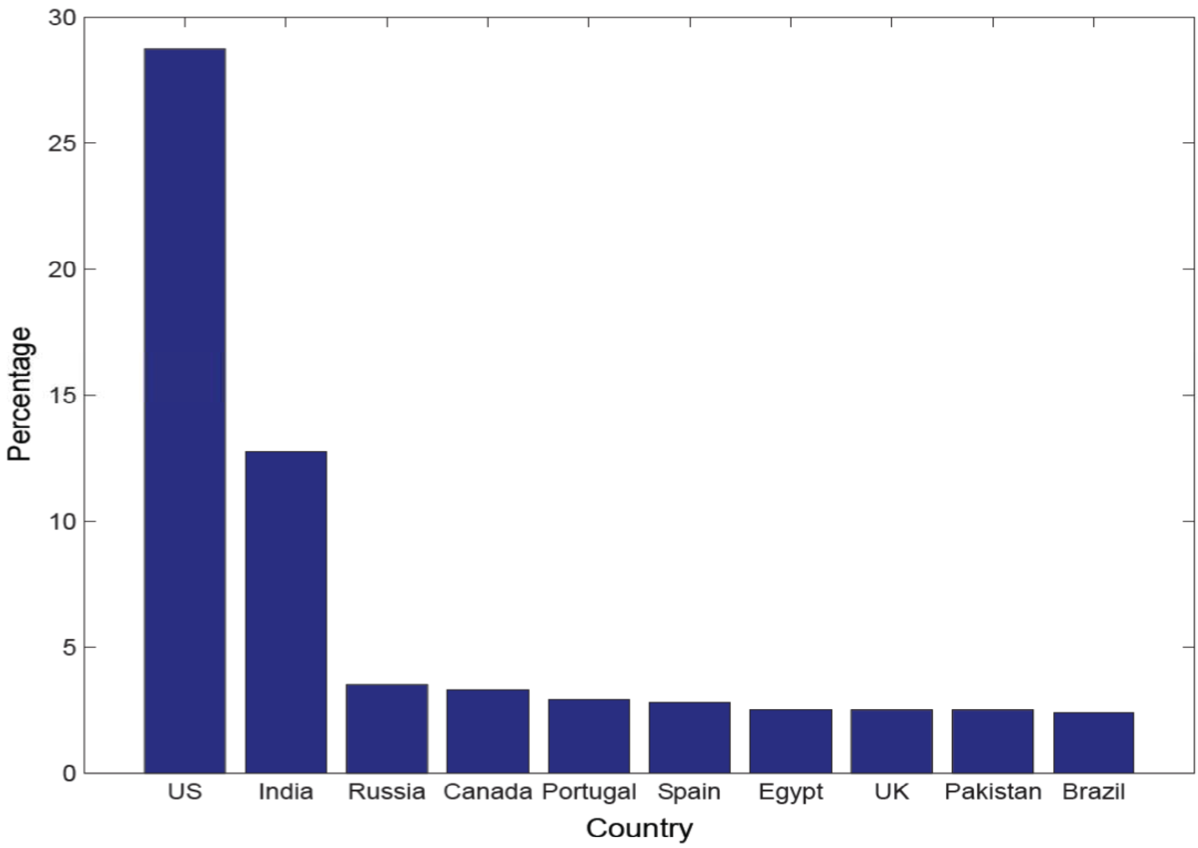
ELEC 241 from Rice over Coursera

- 37,000 students registered (at 5 weeks)
- 10,000 watching the video (at 5 weeks)
- 4,000 working homework (at 5 weeks)
- 257 students took final (at 14 weeks)

Student numbers in 241 MOOC



Country-of-Residence of Students

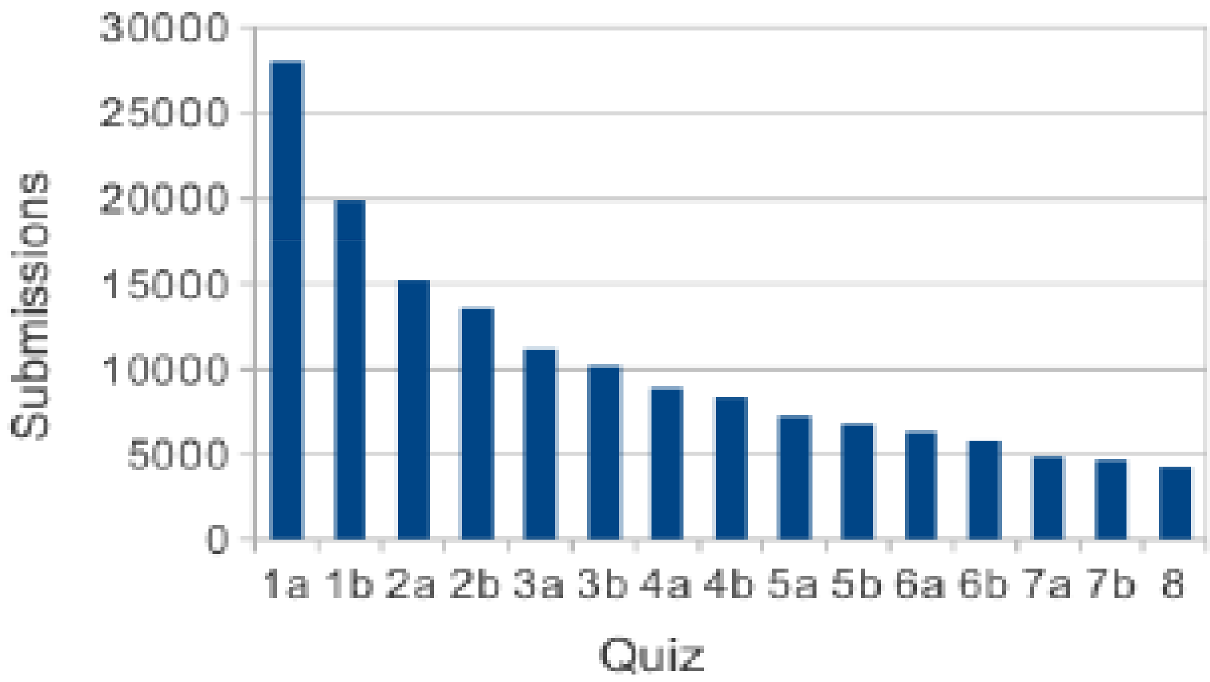


MOOC on *Python* from Rice over Coursera

- 80,000 students registered
- 47,000 watched the first video
- 13,500 did the first project
- 8,100 “completed” the MOOC

this is a “short course”

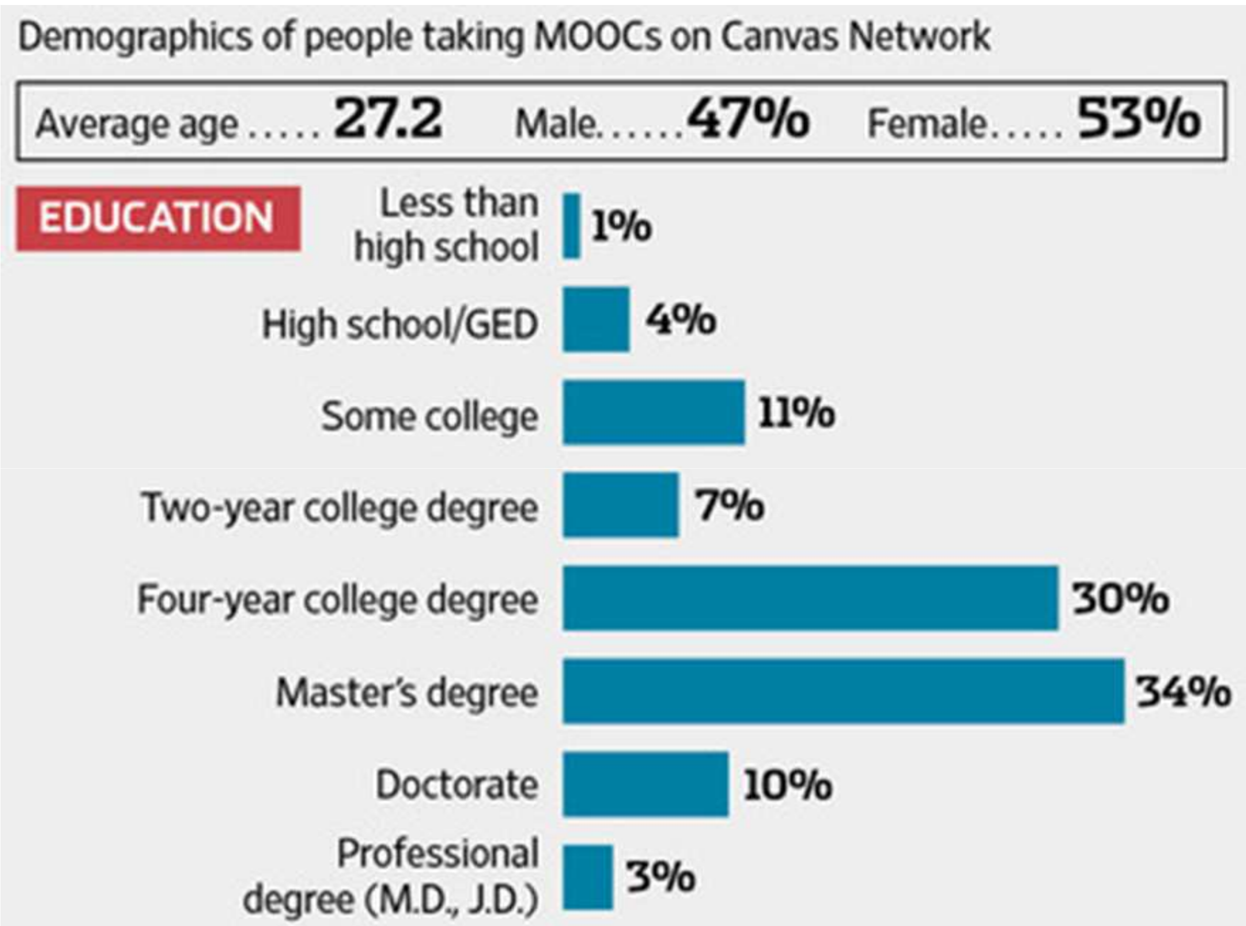
Quiz Submissions



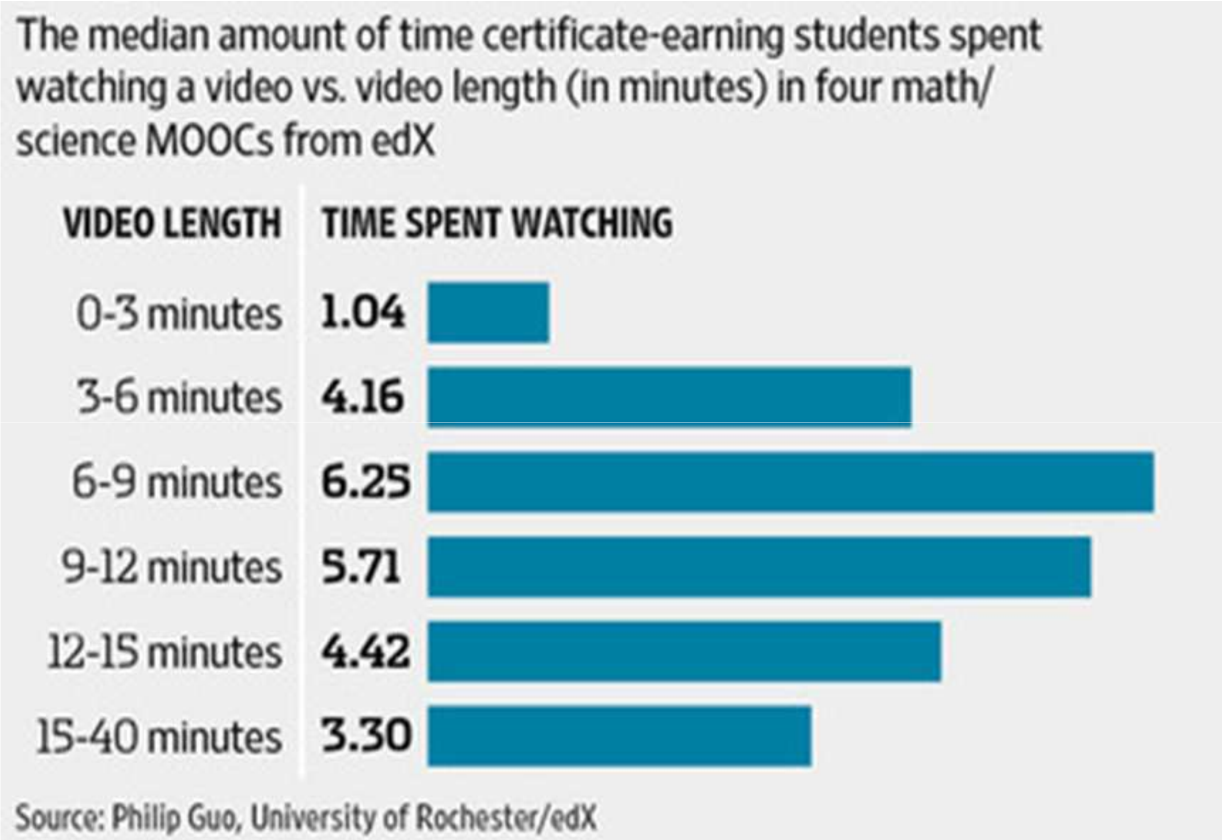
US Views of Online Courses

Inside Higher Ed, October 15, 2013

"A majority of [US citizens] believe online instruction is at least as good as classroom-based courses in terms of providing good value, a format most students can succeed in, and instruction tailored to each individual. But they question the rigor of testing and grading, and whether employers will view such degrees positively, a new survey by Gallup shows".



Source: *Wall Street Journal*, 10/9/2013



Courses from the MOOC provider Coursera with the youngest and oldest students

YOUNGEST	AVERAGE AGE
Probability	28.9
Computer Architecture	30.0
Contraception: Choices, Culture and Consequences	30.3
Introduction to Tissue Engineering	30.3
C++ for C Programmers	30.4
OLDEST	**AVERAGE AGE**
Health Policy and the Affordable Care Act	45.1
The Kennedy Half-Century	44.3
Growing Old Around the Globe	44.1
Modern and Contemporary American Poetry	42.8
Archaeology's Dirty Little Secrets	42.7

MOOCs

MOOCs should be thought of more as an evolution of the **text book** rather than the replacement of a classroom course.

These are Open Educational **Resources**. Remember: books and classes are also Educational Resources; Student learning is the **goal**

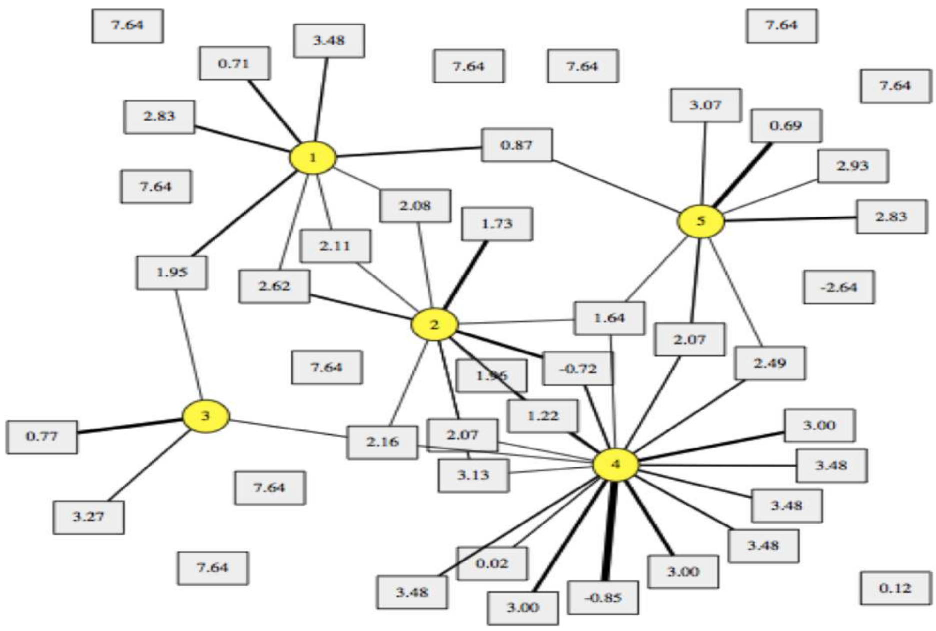
Educational Credentialing

- Credit hours for transferring or as a measure of amount of content
- Certificates or degrees or diplomas
- Badges (as in Boy (or Girl) Scouts)
- Education, assessment, and credentialing may be disintermediated

Personalized Learning

Adaptive learning systems learn from the student’s interactive responses and change for that particular student. Uses *machine learning* methods so it scales

- Uses the same approach used by Amazon, Netflix, etc.
- A scalable version of the Cognitive Tutor
- Rice’s project is called “**OpenStax Tutor**”

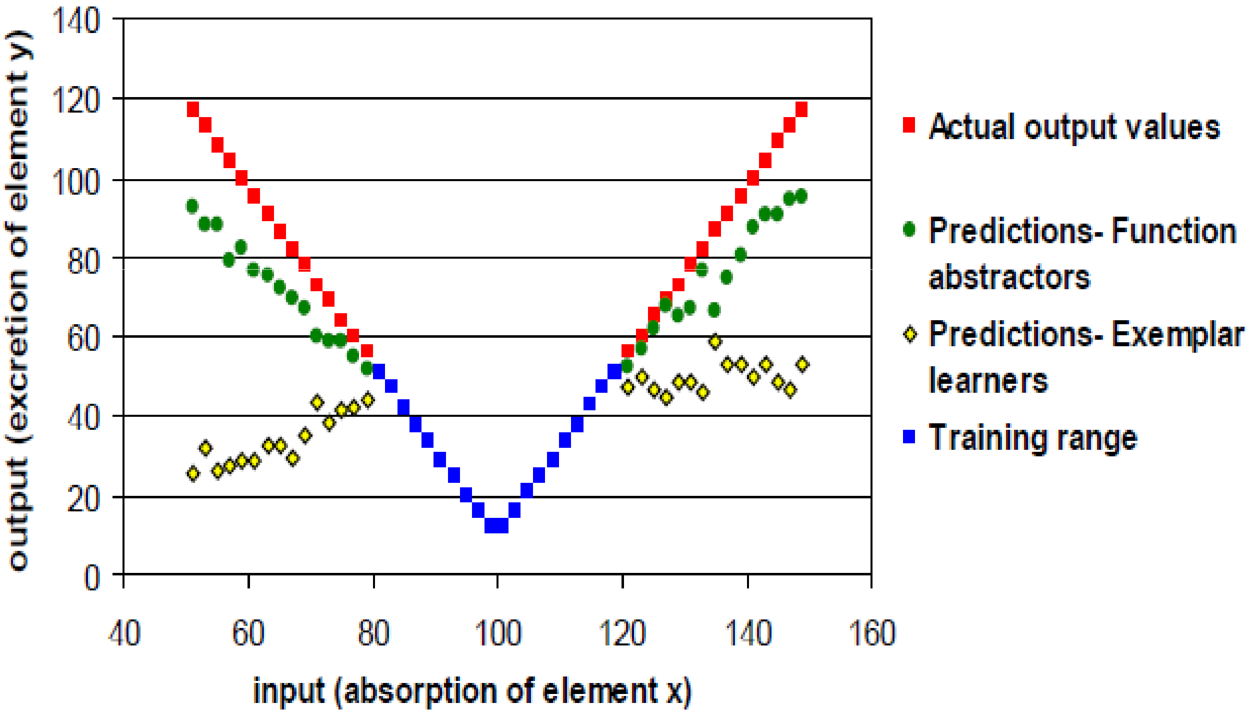


(a) Question–concept association graph. Circles correspond to concepts and rectangles to questions; the values in each rectangle corresponds to that question’s intrinsic difficulty.

Concept 1		Concept 2		Concept 3	
Frequency response	(46%)	Fourier transform	(40%)	z-transform	(66%)
Sampling rate	(23%)	Laplace transform	(36%)	Pole/zero plot	(22%)
Aliasing	(21%)	z-transform	(24%)	Laplace transform	(12%)
Concept 4		**Concept 5**			
Fourier transform	(43%)	Impulse response	(74%)		
Systems/circuits	(31%)	Transfer function	(15%)		
Transfer function	(26%)	Fourier transform	(11%)		

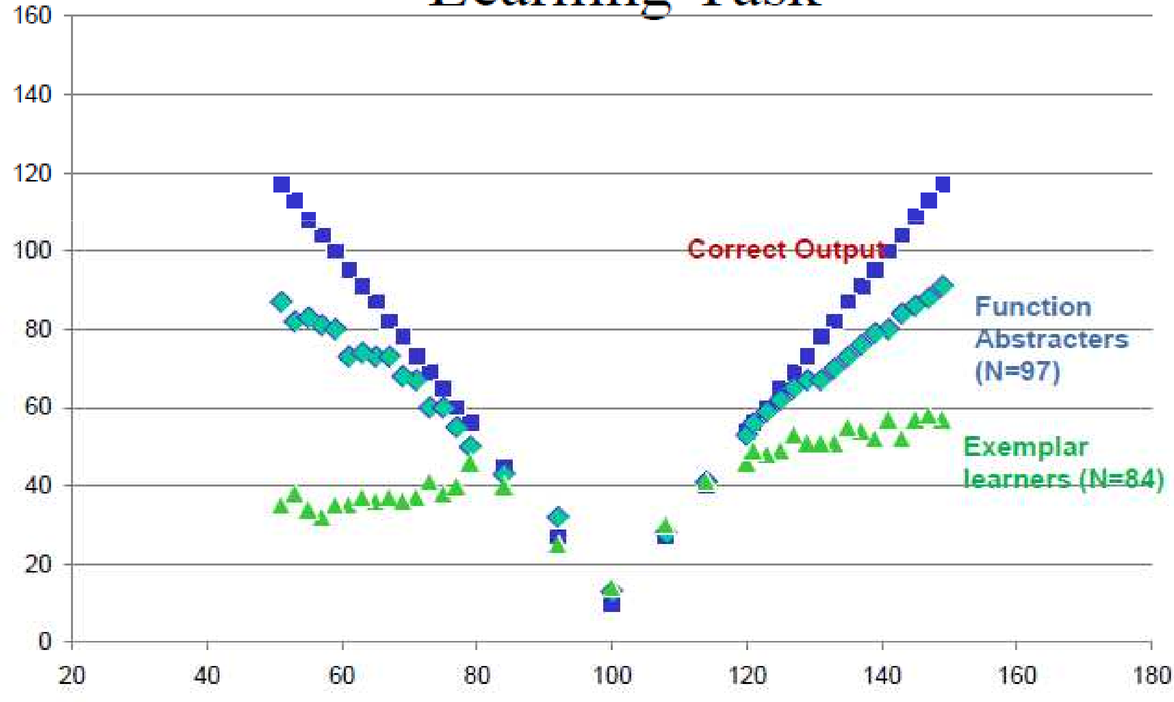
(b) Most important tags and relative weights for the estimated concepts.

Two Ways of Learning



Two Ways of Learning

General Chemistry Results of Function Learning Task



The New World of Education

- Education is changing, a tipping point
- This change is mostly a result of technology, modeling, copyrights, cost, pedagogy; some is political and societal
- The OER, MOOCs, and Badges are often phase one innovation, but the Personalized Learning System is phase two
- The next few years are going to be very interesting, and very important for both public and private education

Application at Rice

- These four revolutions (OER, MOOCs, Personalized Learning, badges) are all experiments
- Rice has the largest OER system in the world (Connexions) and has started OpenStax College
- Rice has developed and deployed three MOOCs (The highest ranked MOOC in the world is from Rice!) and working with both Coursera **and** edX
- Rice has one of the most advanced personalized learning system in OpenStax Tutor

Your assignment

- Go to Connexions web site: http://cnx.org/ find some interesting content and read it.
- Go to a MOOC provider web site: Coursera, Udacity, or edX. Find an interesting course and take it (at least 5 sessions)
- Talk to someone at Connexions or Rice and offer to be an author or reviewer. Develop a collaboration with OpenStax and Rice
- Propose ways that MOOCs and OER can promote education.

Imagine introducing the book

- Imagine a university without books. Instructors and students are literate, but they don’t have books.
- Someone proposes “the book”. The author of the book may be at your university, or at another. It may be good or not
- Imagine the response of the instructor, of the student, of the public
- This is analogous to our response to OER, MOOCs, Badges, and PLS. It is **change!**

"MOOCs, Robots, and the Secret of Life"

Published in *New America Foundation*, by Kevin Carey, 6/7/13

"How much of the vast expanse of what currently comprises higher education can be taught using a technological foundation, at a higher level of quality than what students currently experience, for less money. Not all of it, certainly. But a lot more than people realize or want to admit."

An Op-ed on Higher Education

In ancient times, a "teacher" would stand before a class and read a manuscript to the students. They would write down what the teacher said, trying to do that verbatim. This was *before the advent of printed books*. Indeed, the manuscript being read from was probably hand copied from another copy by a monk or someone else who possibly did not understand the content and, therefore, made many errors. Five hundred or so years ago, technology changed all of that. The movable type printing press allowed accurate, inexpensive books to be available to both teachers and students. ***Only then*** *was mass education a possibility*.

Op-ed on Higher Education

The dramatic change in efficiency and quality of education can only be appreciated in retrospect. There was resistance to this change. There were predictions of failure, shallowness, loss of creativity, students reading about life rather than living it, and all sorts of scary things. However, the overwhelming improvement in efficiency, quality, availability, and the reduced cost overran the resistance and the world of education was irreversably transformed by the **book**.

Resources

- **OER**: OCW at MIT and Connexions at Rice
- **MOOCs**: Coursera, Udacity, edX, and Open2Study
- **Badges**: Mozilla
- **Personalized Learning**: Cognitive Tutor, OpenStax Tutor, etc.
- **Others**: 2U, etc.

edX MOOCs

- **ELEC-301x: Discrete Time Signals and Systems**
  - **Enter the world of signal processing: analyze and extract meaning from the signals around us! Rich Baraniuk, RiceX**
- **PHYS102x: Electricity & Magnetism**
  - **serves as an introduction to electromagnetism, including charge, electric and magnetic forces, induction, current, and resistance. RiceX**
- **8.02x: Electricity and Magnetism**
  - **presents the basic concepts of Electromagnetism, and how this touches upon a vast variety of interesting real-world topics. Walter Lewin, MITx**

Coursera MOOCs

- **Fundamentals of Electrical Engineering**
  - **This course probes fundamental ideas in electrical engineering, seeking to understand how electrical signals convey information, how bits can represent smooth signals like music and how modern communication systems work. Don Johnson, Rice**
- **Linear Circuits**
  - **Learn the analysis of circuits including resistors, capacitors, and inductors. This course is directed towards people who are in science or engineering fields outside of the disciplines of electrical or computer engineering. Bonnie Ferri, Ga-Tech**
- **Digital Signal Processing**
  - **Learn the fundamentals of digital signal processing theory and discover the myriad ways DSP makes everyday life more productive and fun. Prandoni and Vetterli, EPF Lausanne**
- **Fundamentals of Digital Image and Video Processing**
  - **In this class you will learn the basic principles and tools used to process images and videos, and how to apply them in solving practical problems of commercial and scientific interests. Aggelos Katsaggelos, Northwestern**