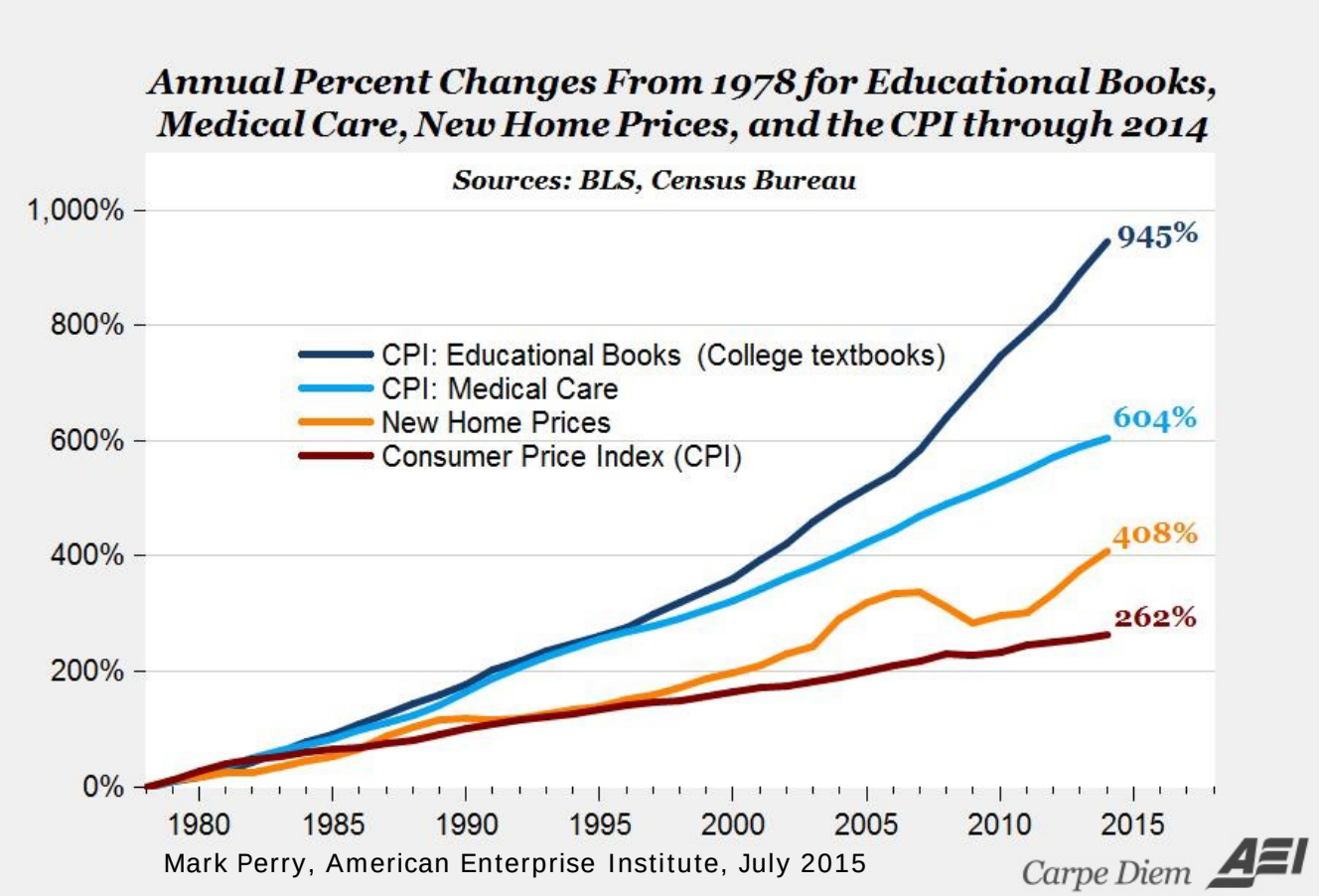
OpenStax College
OpenStax Tutor

Richard Baraniuk

Rice University

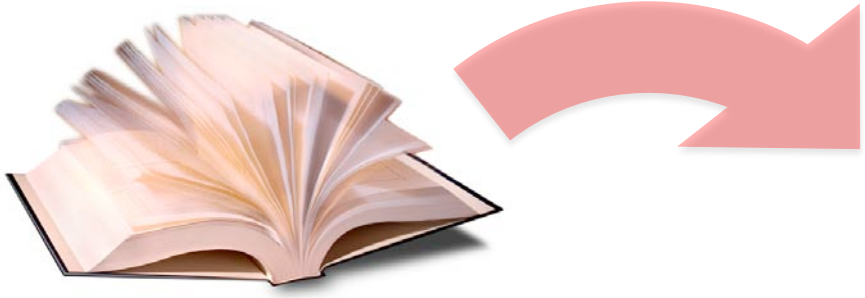
economics gone awry

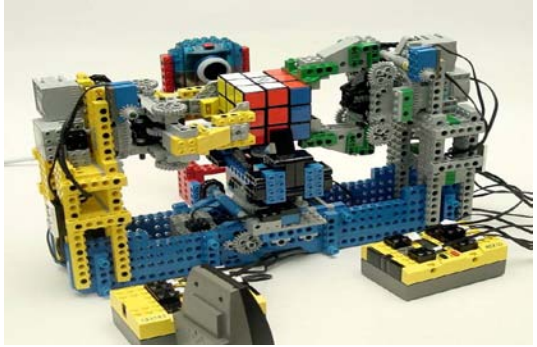


- $400 textbooks
- $1.2T in student debt

vision 1: open education

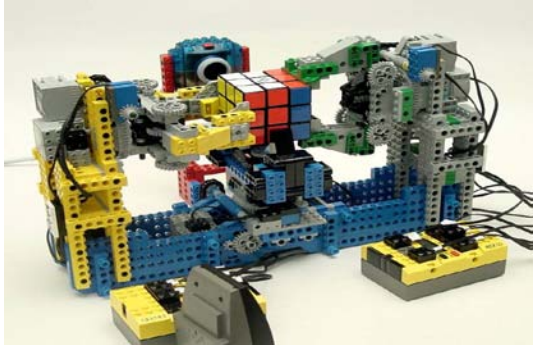
reinvent the textbook





vision 1: open education

reinvent the textbook



~~$$$~~ cc

open college textbooks

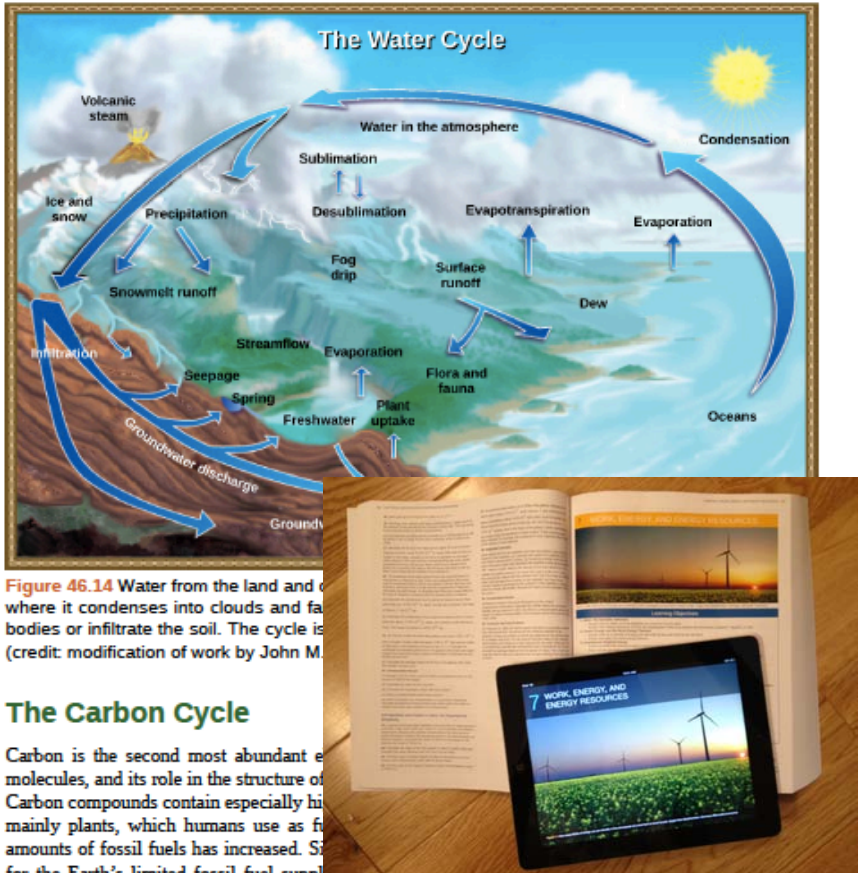


Figure 46.14 Water from the land and
where it condenses into clouds and fa
bodies or infiltrate the soil. The cycle is
(credit: modification of work by John M.

The Carbon Cycle

Carbon is the second most abundant e
molecules, and its role in the structure of
Carbon compounds contain especially hi
mainly plants, which humans use as fu
amounts of fossil fuels has increased. Si

high quality

- professionally authored
- professional production values
- peer reviewed

turnkey adoptable

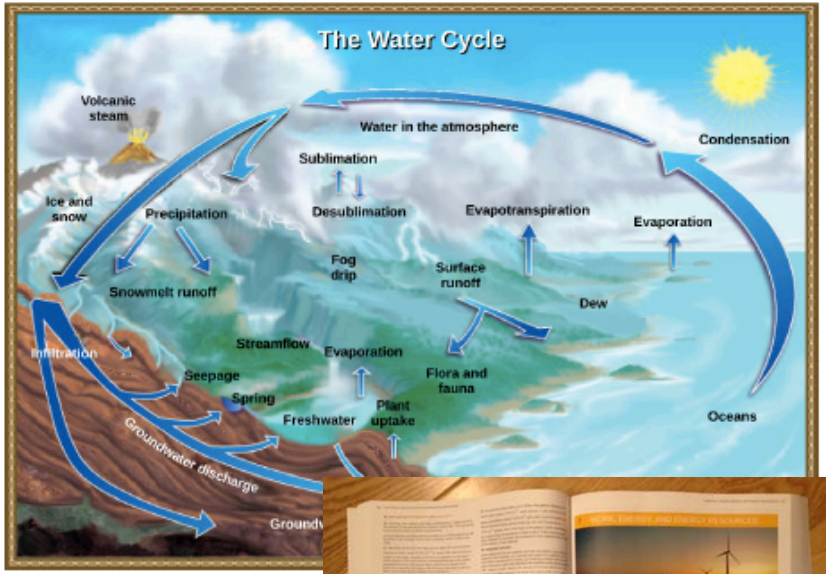
- text + ancillaries
- multiplatform

free / open

- easy access
- customizable

open college textbooks

openstax COLLEGE



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venture philanthropy

ROI in student savings

THE WILLIAM AND FLORA HEWLETT FOUNDATION

ljaf laura and john arnold foundation

RICE

BILL & MELINDA GATES foundation

MAXFIELD FOUNDATION

THE CALVIN K. KAZANJIAN ECONOMICS FOUNDATION

20MM TWENTY MILLION MINDS FOUNDATION

LEON LOWENSTEIN FOUNDATION

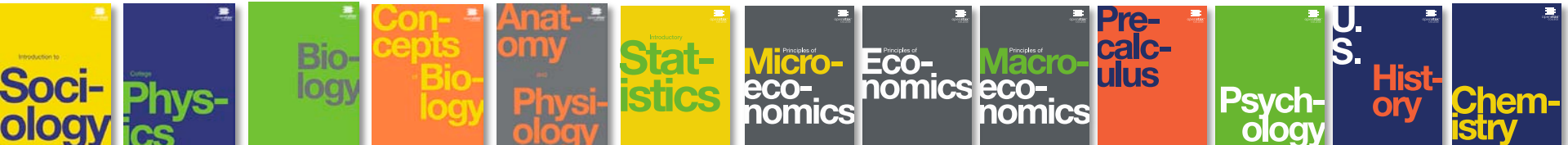
2200 adoptions at 1200 institutions, saving 650,000 students over $60M in the 3 years since launch

- 20% of degree-granting institutions are using at least one OpenStax text
- hundreds of community colleges and high schools but also Stanford, Princeton, Ohio State, U Georgia, U Mass, UT Austin, Rice, …

8 million informal learners

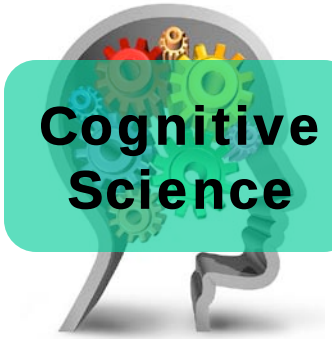
openstax COLLEGE

College Algebra
Algebra and Trigonometry
Sociology 2nd Edition
Basic College Math
Elementary Algebra
Calculus
Microbiology
University Physics
Intermediate Algebra
Astronomy
Finite Math
Introduction to Accounting
Introduction to Management
American Government
AP Physics 1&2
AP Biology
AP Principles of Economics
High School Physics



vision 2: personalize education

data



Cognitive Science → **Machine Learning**

close the learning

feedback loop

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BACKUP SLIDES

ecosystem of partners

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sapling learning
engaging students, empowering educators

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simbio

nacscorp
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ANATOMYZONE

inkling

EXPERT ta

amazon.com

TOP HAT

RedShelf™

MBS DIRECT
Textbooks & Course Materials

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OCAD U

Lrnr
Adaptive Learning Solutions

packback

lumen

VERITAS TUTORS

MyOpenMath

xyz homework

Chegg
don't buy it

COURSELOAD

classical approach – **knowledge engineering**

- domain experts pore over content, assessments, data, tagging and building rules
- fragile, expensive, not scalable, not transferable

modern approach – **machine learning**

- learn directly from data
- automatic
- robust, inexpensive, scalable, transferable

Google

NETFLIX

amazon

gradebook.xlsx

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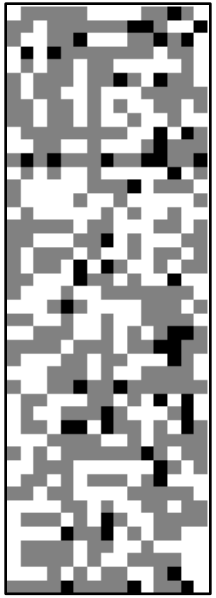
Q23

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1	STUDENTS						PROBLEMS								SCORE	GRADE
2		Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12		%	
3	Susan	8	7	2		3		10	10		9		9		78	B
4	Juan	9	10		7	0	9	10		3	3		6		68	C
5	Eva		10		10		0	8		9	9				90	A+
6	Neelsh	8	9		9	7	8	9		0	8				88	A
7	Nora	8		4	6					6	6		9		66	C
8	Sydney	9		8			5	4		9	5				54	C-
9	Barbara				6			5			9				44	F
10	Sarah	10		10	10		8			7	7		8		88	A
11	Nicholas	5		6		7		6	7	9	8		8	...	77	B
12	Vivek		2		5		5	5		5	8		10		54	D
13	Agnes	7	9			7		6	9		7		4		86	A
14	Angus	9	9		5		5		3		8		8		65	C
15	Sheila	1	7		7	7		5		9	9		9		83	B+
16	Mike	7			8	8		6		0	9		7		59	C-
17	Megan	4		9		8	8	10	10		8				89	A
18	Isabella		6	7		4		9	3	0	5				71	B
19	Mateo		4	9		10	10	10	4	0	7		3		89	A
20	Sofia		3	4		9	9	7			3		10		74	B

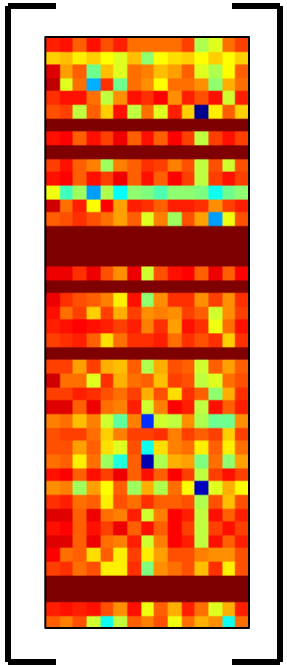
statistical model

students

problems



$\sim Ber\Phi$



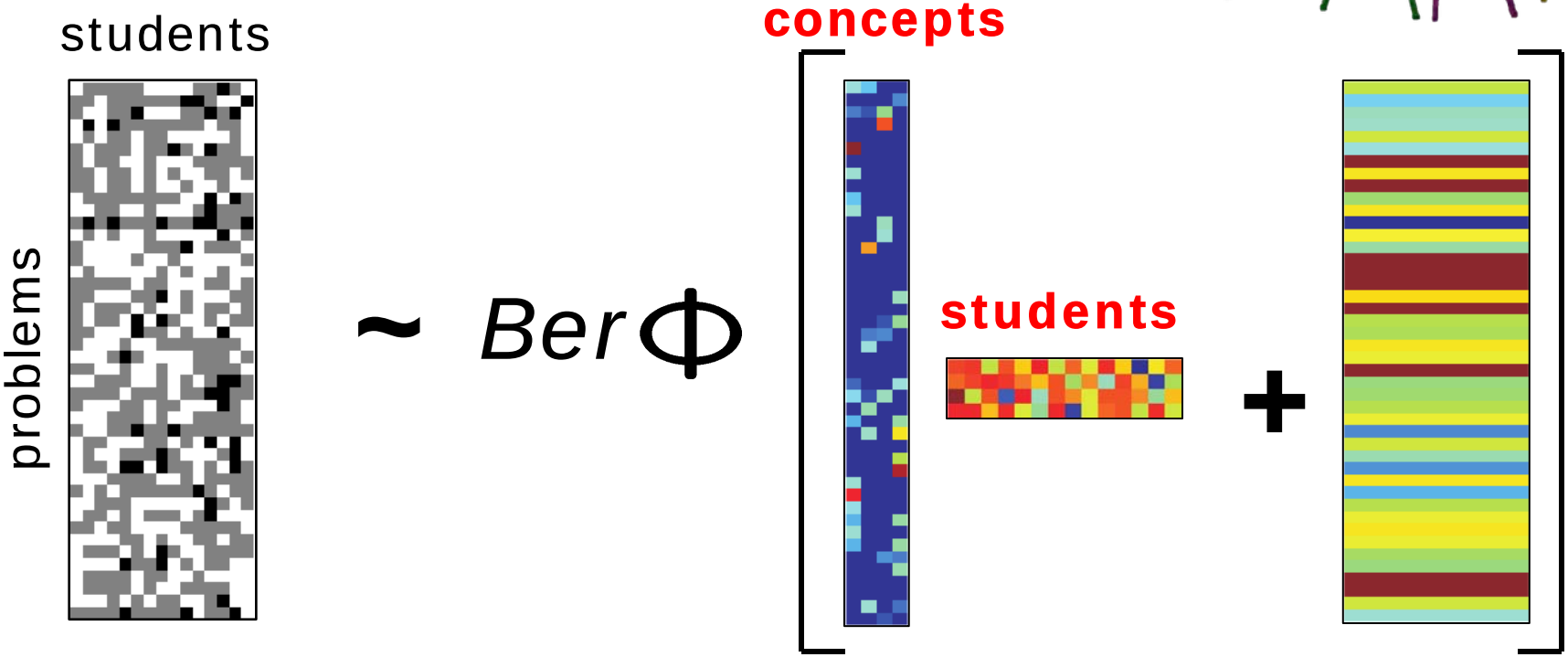
red = strong ability

blue = weak ability

converts to 0/1
(probit or logistic
coin flip transformation)

estimate of each student's ability
to solve each problem
(even unsolved problems)

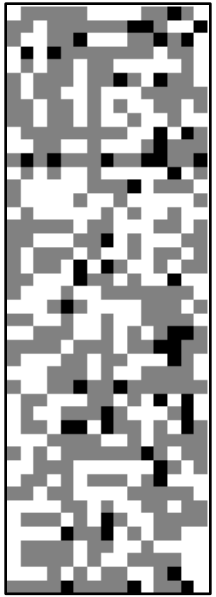
SPARse Factor Analysis



SPARFA™

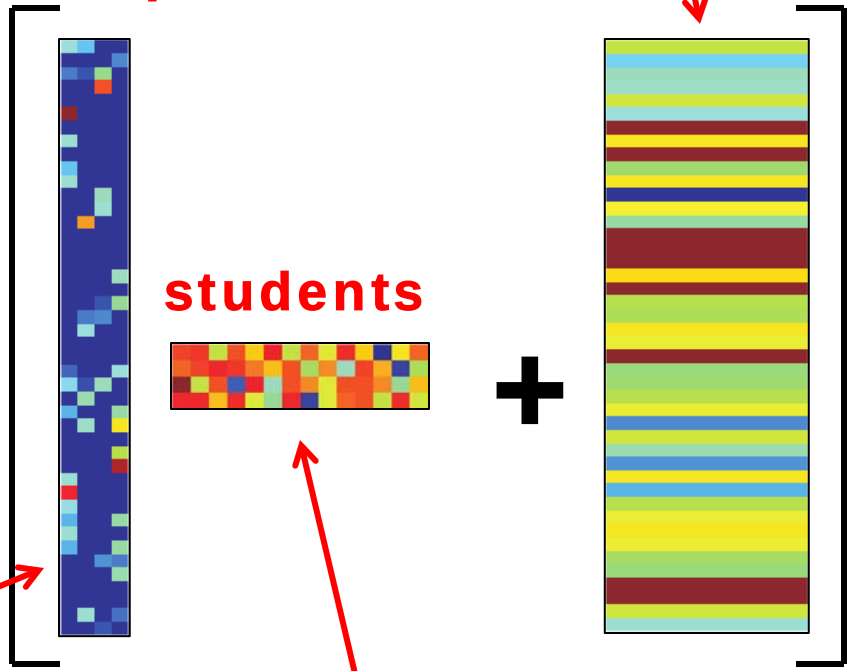
students

problems



$\sim Ber\Phi$

concepts

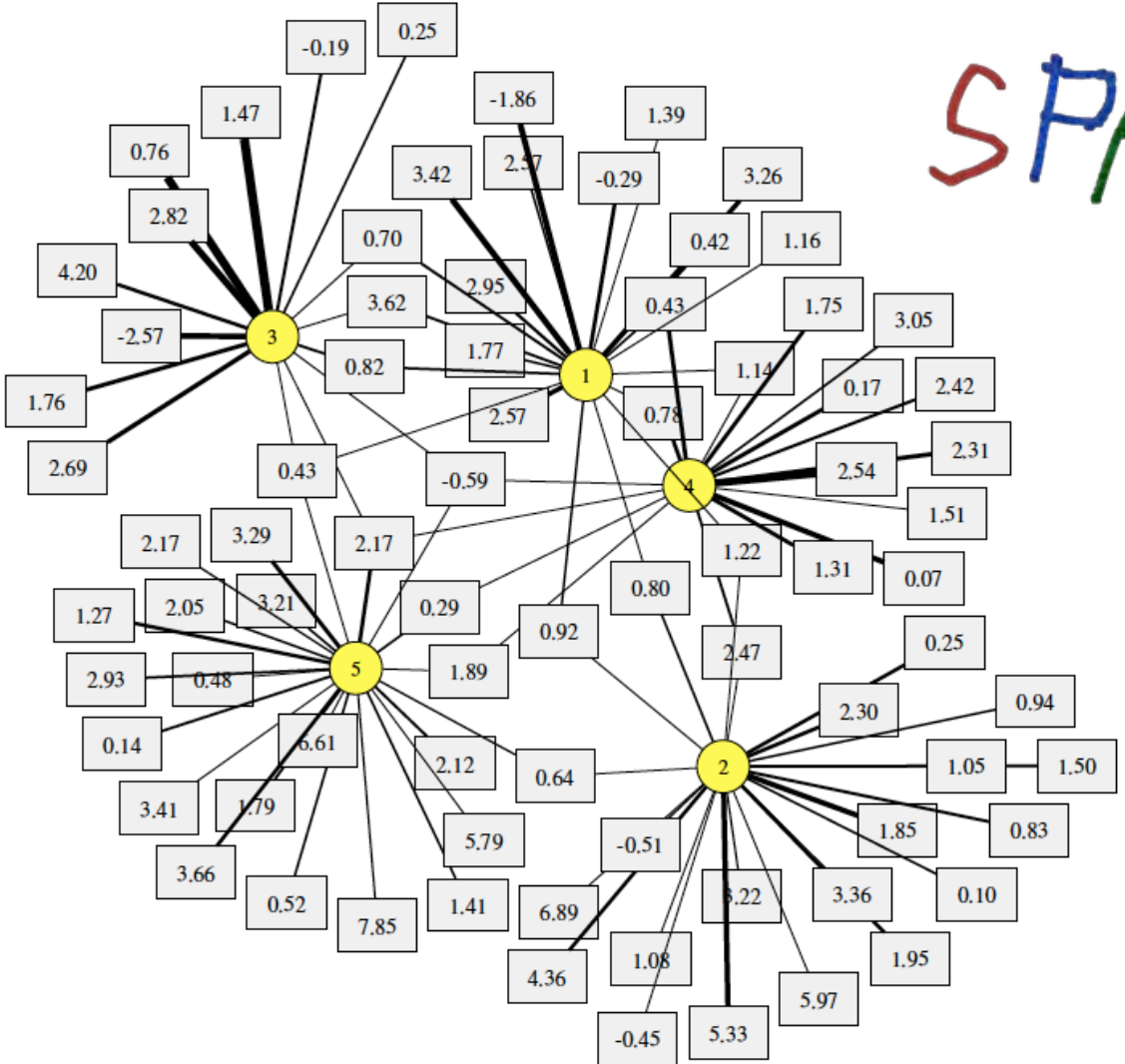


students

each problem's intrinsic "**difficulty**"

each problem involves a combination of a small number of key "concepts"

each student's knowledge of each "concept"


3
1
4
5
2
-0.19
0.25
1.47
0.76
2.82
4.20
-2.57
1.76
2.69
-1.86
1.39
3.42
2.57
-0.29
3.26
0.70
0.42
1.16
2.95
3.62
0.43
1.75
3.05
1.77
0.82
1.14
0.17
2.42
2.57
0.78
2.31
0.43
-0.59
2.54
1.51
2.17
3.29
2.17
1.22
1.31
0.07
1.27
2.05
3.21
0.29
0.80
0.92
2.47
0.25
2.93
0.48
1.89
2.30
0.94
0.14
6.61
2.12
0.64
1.05
1.50
3.41
1.79
5.79
-0.51
1.85
0.83
3.66
0.52
7.85
1.41
6.89
3.22
3.36
0.10
1.08
1.95
4.36
5.97
-0.45
5.33

SPARFA tm

SPARFA™

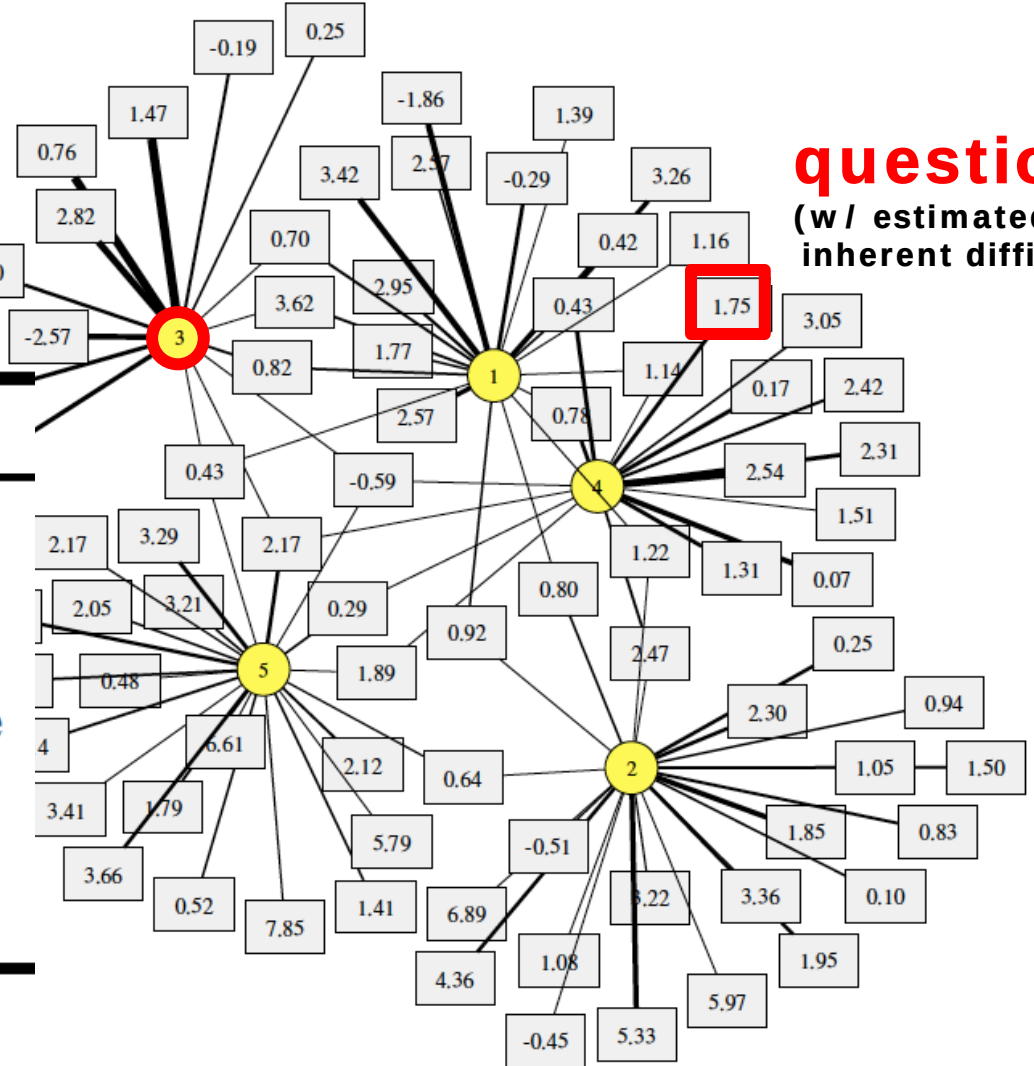
concepts

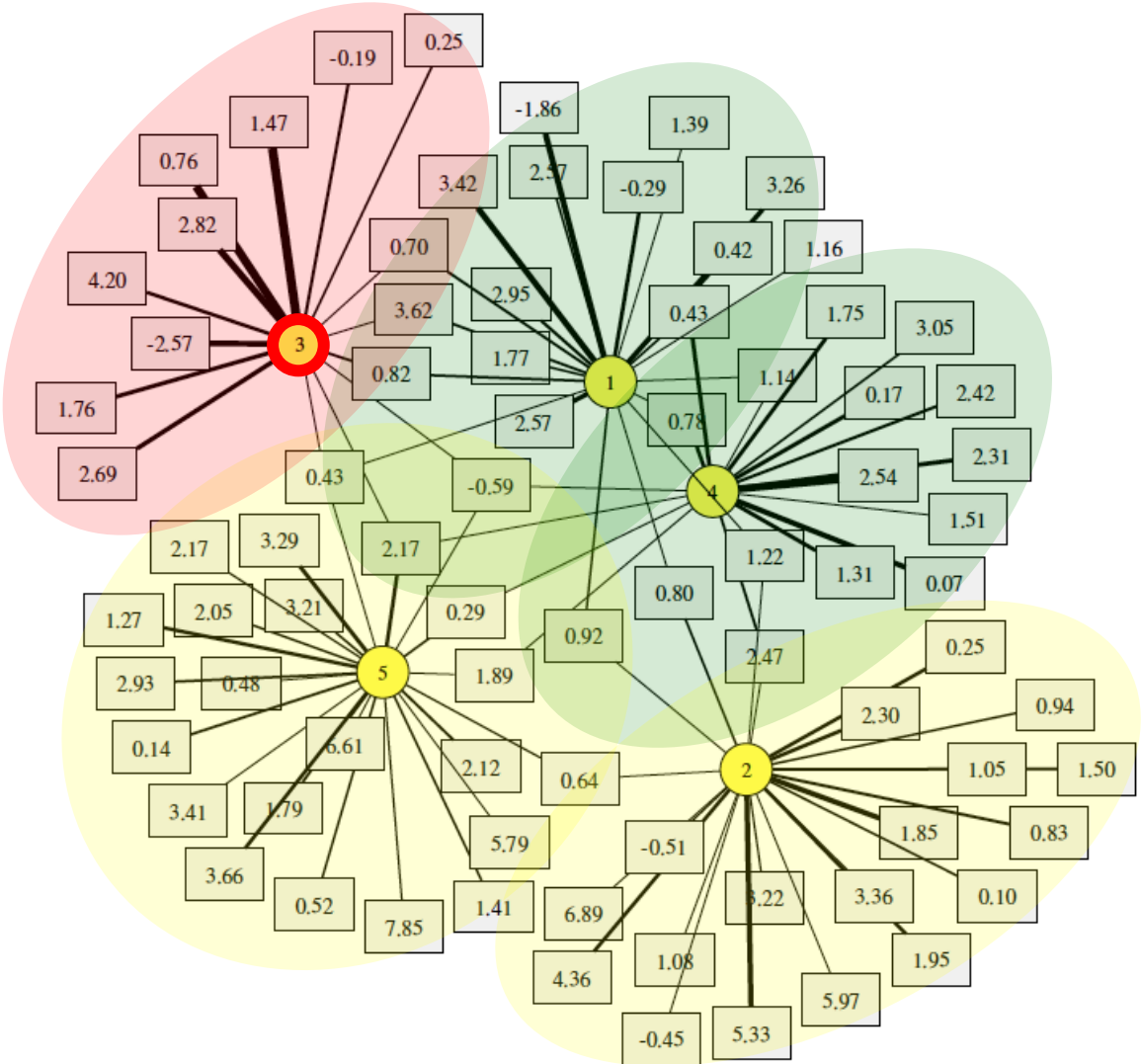
Concept 3

Energy
Light
Thermal
Temperature
Bulb
Grams
Noise

questions

(w/ estimated inherent difficulty)





Susan

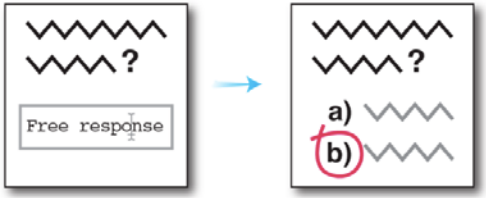
B

87
55
23
93
62

student knowledge profile

retrieval practice

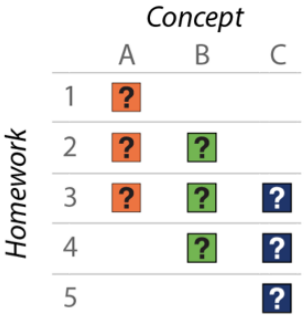
- retrieving information from memory is not a neutral event; rather it ***changes*** memory



two-step answer process engages students in retrieval practice

spacing

- distributing practice over time produces better long-term **retention** than massing practice



spaced concept practice

feedback

- closes the learning **feedback loop**
- must be timely

timely, informative feedback

flexible platform for practice, assessment, and learning research

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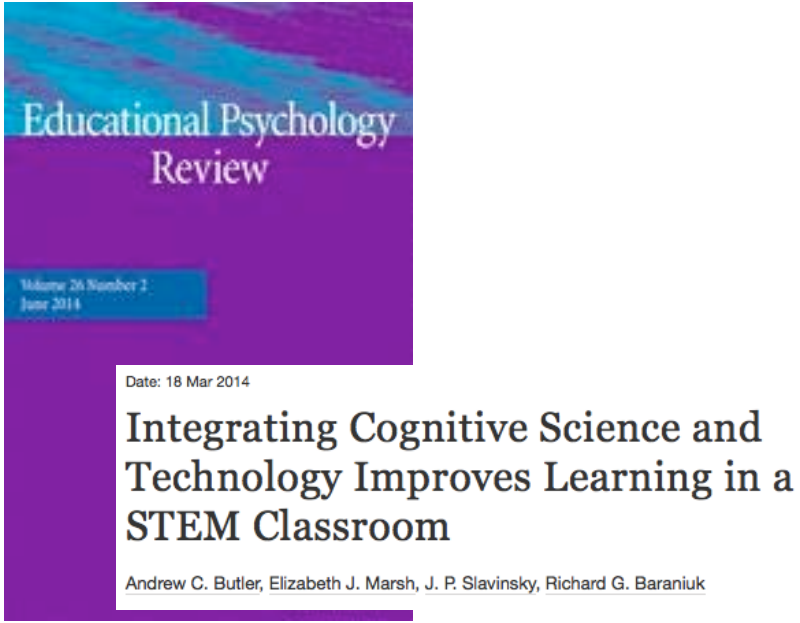

- experiment at Rice 2012
- findings: students using cognitive science principles in OST scored **½-1 GPA point better** than those using standard practice homework
- many experiments ongoing

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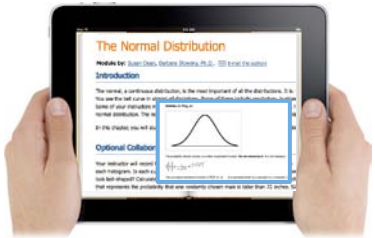

curriculum (re)design

tune teaching / learning model

personalized learning pathways

district implementation

learning science research

big data