Slide 1

Student test scores in math computation and the implications for chemistry instruction

Presented 8/2/2010 at the
Cognition Symposium of the
ACS Biennial Conference on Chemistry Education (BCCE)
By Rick Nelson, Retired Instructor
EANelson@ChemReview.Net

1

Good Morning.
Let me begin with an apology. I am going to go fast,
But at the end I will put up a web address where you may
Review at your leisure any slides that you might find interesting.

Slide 2

In my view,

(Vote for ONE:)

In **first**-year chem, the ***math background*** of entering students is:

A. A major problem
B. A minor problem
C. Not a problem

2

To start, I'd like to ask you to please **read** this question

-- then be ready to vote for A, B, or C.

Ready? How many of you would vote (raise your hand) for A, _____ B? _____ C? _____

Good. Try question 2.

Slide 3

Vote for ONE:

In 1st year chem, it is *most* important for students to have **background knowledge** in

A. Use of a calculator
B. The theory of mathematics
C. Math computation

3

Please read and be ready to vote….

In chemistry, we ask students
To solve problems like THIS

Slide 4

$$\mathscr{E} = \mathscr{E}^\circ_{\text{cell}} - \frac{0.0591}{n}\log(Q)$$

$$= 1.76 - \frac{0.0591}{2}\log\left(\frac{[Zn^{2+}][VO^{2+}]^2}{[VO_2{}^+]^2[H^+]^4}\right)$$

$$= 1.76 - \frac{0.0591}{2}\log\left(\frac{(1.0\times10^{-1})(1.0\times10^{-2})^2}{(2.0)^2(0.50)^4}\right)$$

$$= 1.76 - \frac{0.0591}{2}\log(4\times10^{-5}) = 1.76 + 0.13 = 1.89\ \text{V}$$

-- Zumdahl, 5th edition

4

and THIS

Slide 5

$$\mathcal{M} = \frac{dRT}{P}$$

$$= \frac{(3.09\ \text{g/L})(0.0821\ \text{L-atm/mol-K})(304\ \text{K})}{(735/760)\ \text{atm}}$$

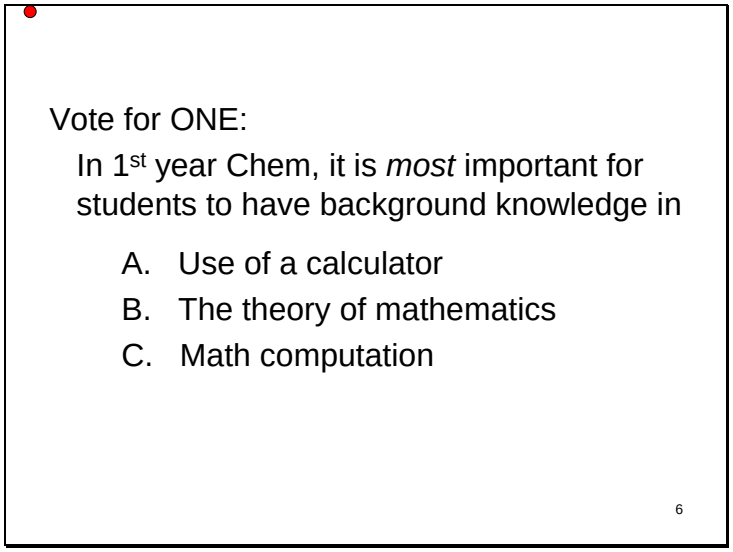
$$= 79.7\ \text{g/mol}$$

-- Brown, Lemay, 8th Ed. p. 368

5

Or this

Slide 6

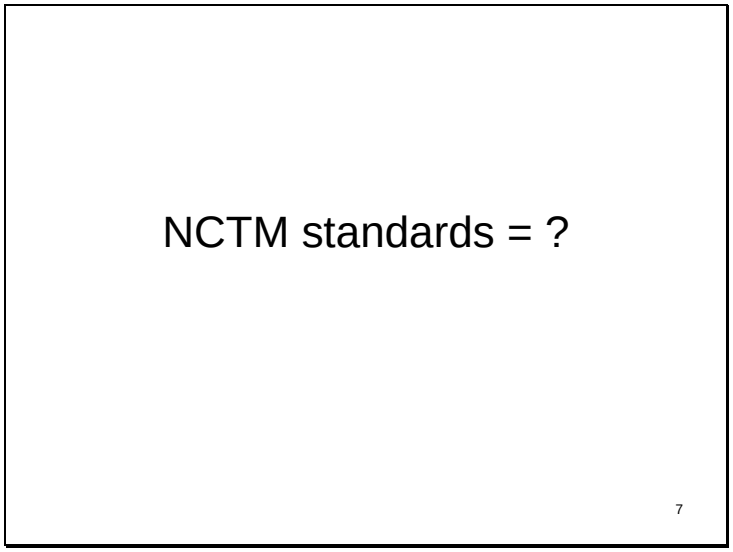


All of these 3 are important.

But if you had to pick ONE, Which is most important?

How many vote for A: _____ B: _____ C: _____

Slide 7



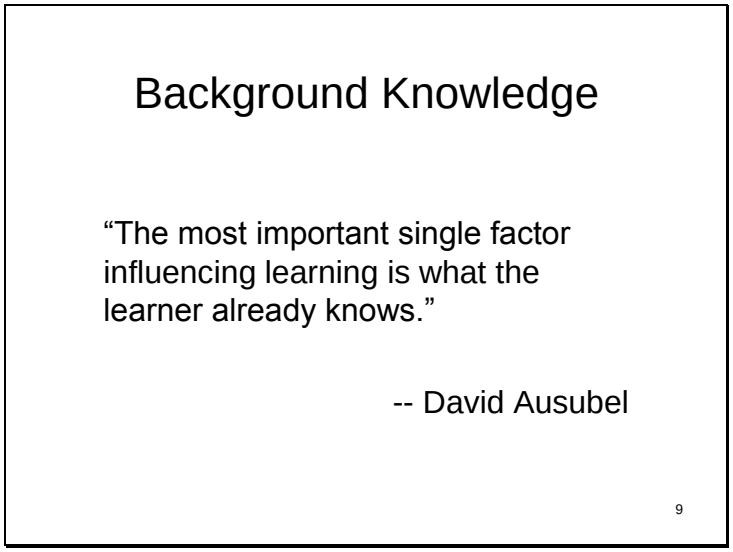
Question 3
If you are familiar with the NCTM standards,
please raise your hand?
OK.

Slide 8

Finally ….

Theorists – be patient.
I am going to argue that
In applying constructivism, math
Is different from chemistry.
Bear with me.

Slide 9



Whatever your theoretical beliefs, just about everyone agrees that Background knowledge is important in learning.

(And as you indicated by your vote,
The background knowledge that we especially depend on in chemistry is in math computation
Which you also voted was a major problem.)

Let's look at the evidence. (Is computation background a problem?
If so, WHY? And how can we fix the problem?)

Slide 10

Virginia Math Results:

- Stanford 9 standardized test given **statewide**
- National percentile median = 50 on 1995 norms

VA all students	Grade 9				
	1998	1999	2000	2001	2002
Total Math	54	55	55	55	55

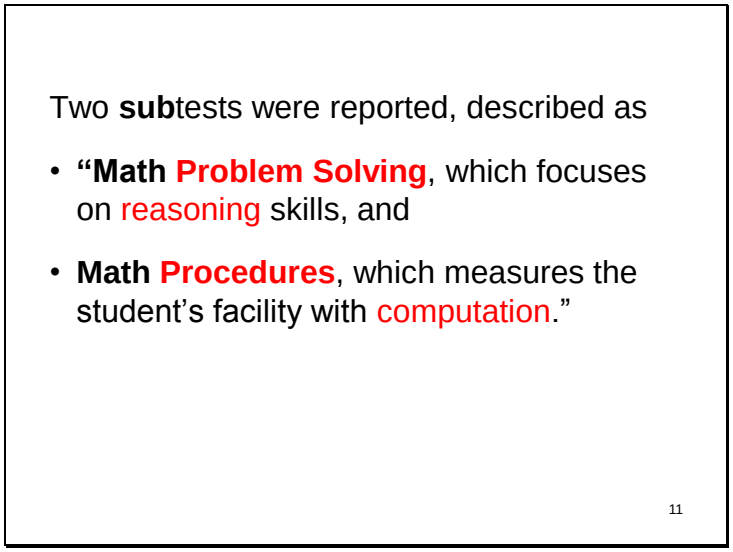
10

n2
About 8 years ago, I was representing my faculty organization
On a task force looking at
why so many students entered college needing math remediation.

When I looked at the Virginia test scores, in “Total Math”
Our students were above national median 50th percentile -- and steady. (point)

But to a chem instructor, that didn’t look right. So
I looked in the report detail, where I found that on the test Virginia was using

Slide 11



There were two subtests. "Total math" was a combination of

→ "Problem solving" which measured reasoning

And "procedures" which measured computation.

Slide 12

Virginia Math Test Scores

VA Stanford 9	Grade 9				
	1998	1999	2000	2001	**2002**
Total Math	54	55	55	55	55
Problem Solving	**58**	61	63	64	**65**
Procedures	**46**	44	42	41	**39**

All state 9th graders: 80,000 students/year in 134 independent districts.

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The subtests showed that student scores
→ in reasoning were high and going higher,
But in computation were low and going lower.

These data say that

Slide 13

Virginia Math Test Scores

VA Stanford 9	Grade 9				
	1998	1999	2000	2001	**2002**
Total Math	54	55	55	55	55
Problem Solving	**58**	61	63	64	**65**
Procedures	**46**	44	42	41	**39**

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1. Knowing “total math” tells you nothing about math computation.

2. Teaching “reasoning” did not teach students how to solve calculations. There was no transfer.

- In math computation, when your state average is at the 39th percentile, Not many kids are going to be ready for the rigor and pace of college general chemistry.

Slide 14

VA Stanford 9	Grade 9				
	1998	1999	2000	2001	**2002**
Total Math	54	55	55	55	55
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14

Finally, since these numbers are for 130+ independent school districts
Choosing whatever curricula and textbooks they want
Is Virginia's 39th percentile a random sample of America?

Slide 15

VA Stanford 9	Grade 9				
	1998	1999	2000	2001	**2002**
Total Math	54	55	55	55	55
Problem Solving	**58**	61	63	64	**65**
Procedures	**46**	44	42	41	**39**

- "Total Math" hides math computation.
- Reasoning did not help computation.
- 39th percentile = not ready for chemistry
- 134 independent districts = sample of nation?

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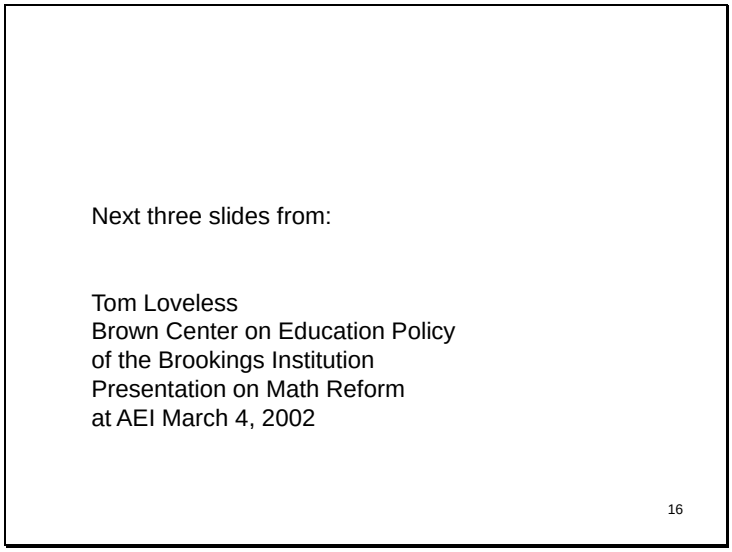
Finally, since these numbers are for 130+ independent school districts
Choosing whatever curricula and textbooks they want
Is Virginia's 39th percentile a random sample of America?

Slide 16



I went looking for more data,
and found this report online from
Tom Loveless at the Brookings Institution

Tom said the best data was for the state of Iowa.

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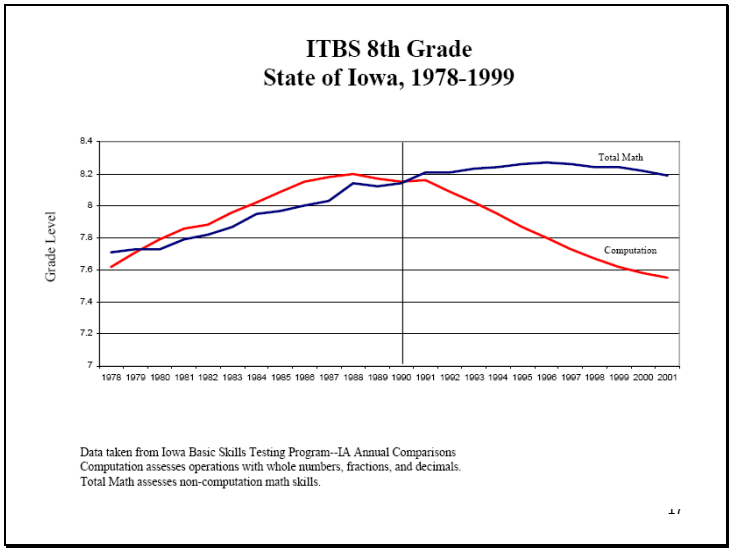

Like Virginia,
Each Iowa district does its own textbook adoption.
And Iowa also required state testing in every district.
But -- Iowa gave the same test for over 20 years.

The BLUE line is “total math” and the RED line is computation
Both went up between 1978 and 1990
But starting in 1990, total math flattens out -- and computation goes down --
Just like Virginia during this period.
And, like Virginia, “total math” does not predict scores in computation.

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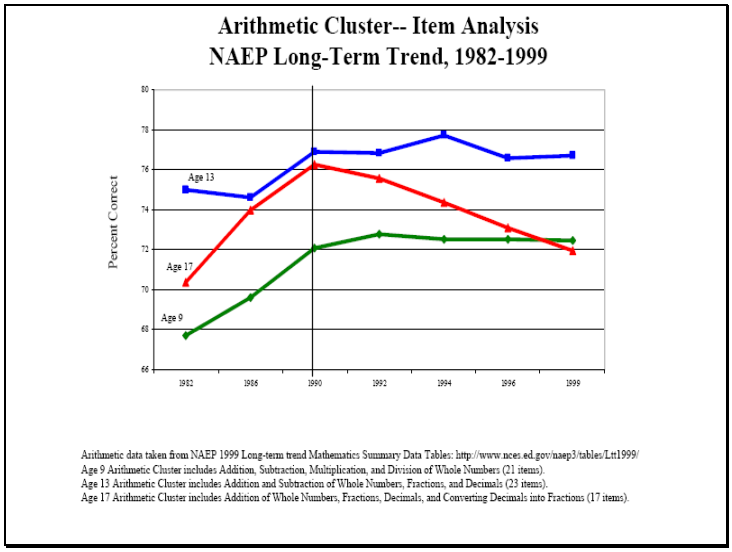
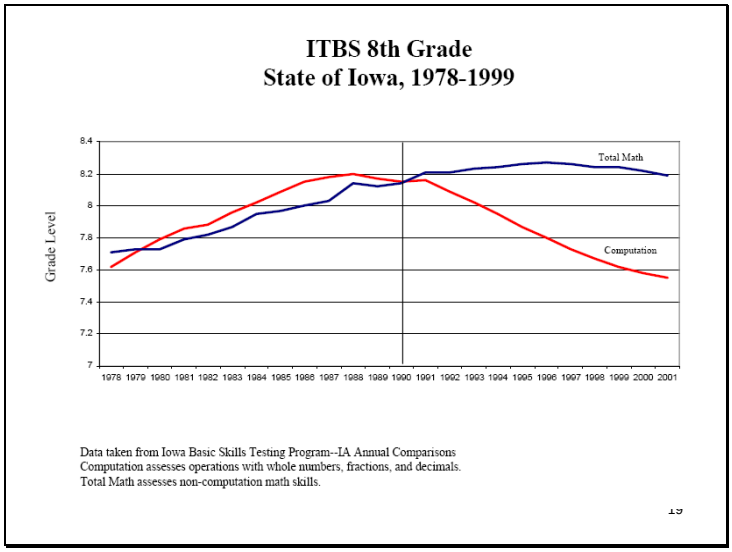


Dr. Loveless also looked at a nation-wide measure:

The National Assessment of Educational Progress
(NAEP -- the “nape”) the “nation’s report card,”
Given every two years in every state.

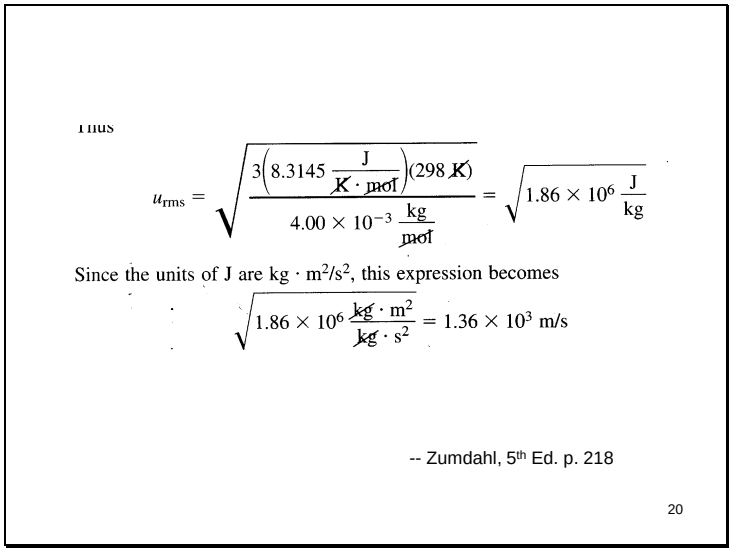
For the oldest group -- 17 year olds in red --
Tom looked at the arithmetic that we do a lot of in chemistry
And found that scores went up from 1982 to 1990
But after **1990**, went down.

Slide 19



Just like for COMPUTATION in Iowa

Slide 20



Thus

$$u_{rms} = \sqrt{\frac{3\left(8.3145 \frac{J}{K \cdot mol}\right)(298\ K)}{4.00 \times 10^{-3} \frac{kg}{mol}}} = \sqrt{1.86 \times 10^{6} \frac{J}{kg}}$$

Since the units of J are $kg \cdot m^2/s^2$, this expression becomes

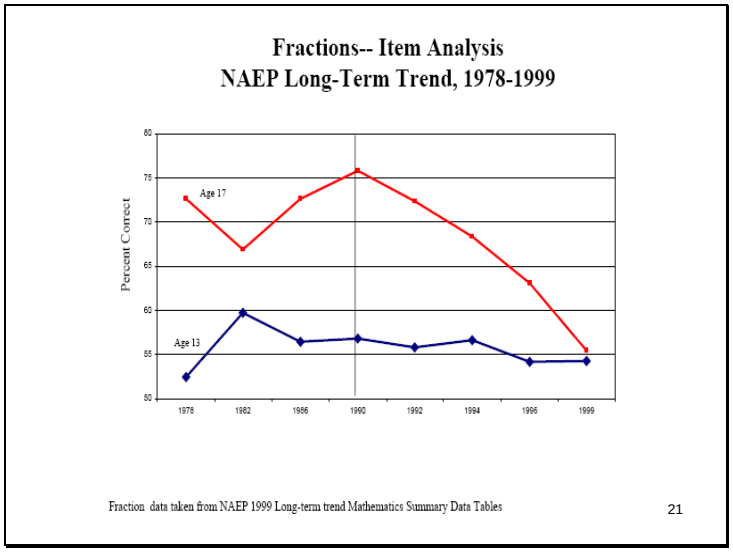
$$\sqrt{1.86 \times 10^{6} \frac{kg \cdot m^2}{kg \cdot s^2}} = 1.36 \times 10^{3}\ m/s$$

-- Zumdahl, 5th Ed. p. 218

20

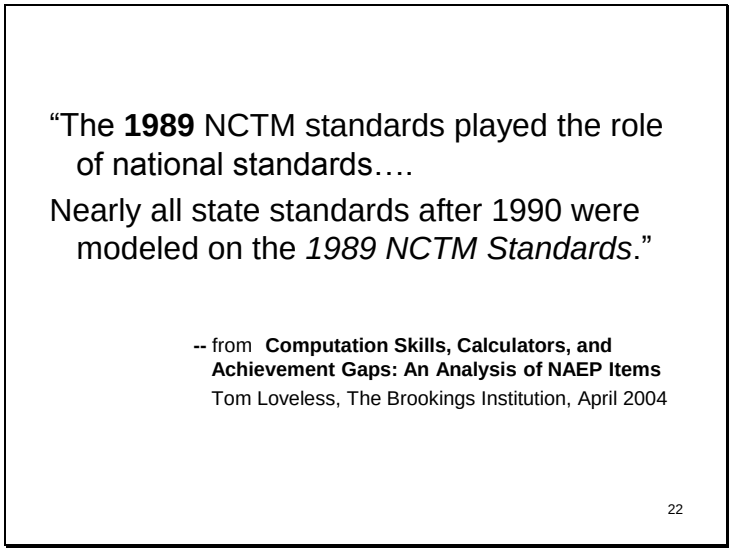
In chemistry, we do some fractions.
Dr. Loveless looked at fractions on the NAEP:

Slide 21



And found , for the 17 year olds in red, fluctuation,
Then a dramatic decline -- after 1990.
There is a LOT more data, but the evidence is consistent and convergent.
Computation goes down after 1990.
Why?

Slide 22



n520
In his paper, Dr. Loveless says this:
Take a look.

Slide 23

The Math Wars

Short history:

A quarter century of US 'math wars' and political partisanship

David Klein

California State University, Northridge

http://www.csun.edu/~vcmth00m/bshm.html

longer version:

http://www.csun.edu/~vcmth00m/AHistory.html

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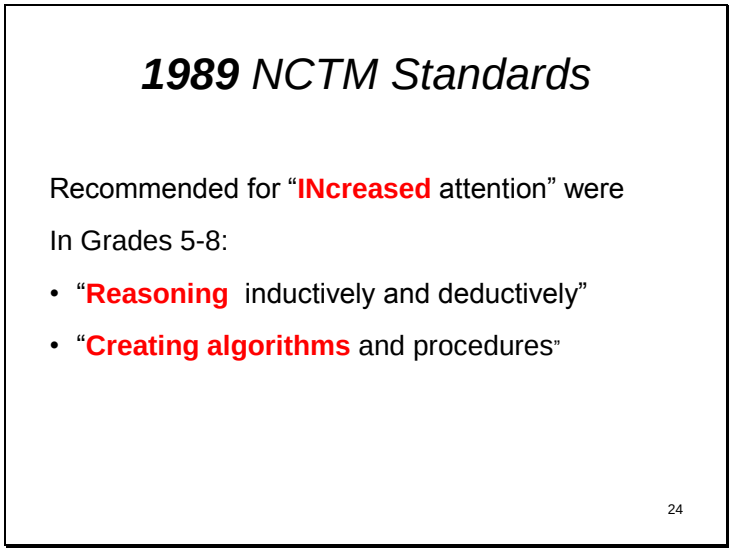
What's this about?
You can find more information in my slides at these references. But briefly:
The NCTM is the National Council of Teachers of Mathematics
They publish policy statements on K-12 math curriculum.

Slide 24



In 1989, NCTM published their "standards"
That became the standards in nearly every state.

The NCTM standards favored reasoning. That's good.

But the NCTM said 5th graders should be **constructing** their own math algorithms.

The NCTM standards are a version of the learning theory called constructivism
Perhaps carried to an extreme.

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1989 *NCTM Standards*

Recommended for "**DEcreased** attention" were

- "Finding **exact** forms of answers"
- "Memorizing **rules** and **algorithms**"
- "**Manipulating symbols**"
- "Paper and pencil **fraction** computation",
- "Relying on **outside authority** (teacher or answer key)"
- "Rote **practice**"
- "Long division"

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For example,
The NCTM said math teachers should

Decrease attention to arithmetic
Decrease attention to algebra
Decrease attention to fractions.

If students do not practice
Arithmetic, algebra, and fractions
What's going to happen to them when they get to

Slide 26

Thus

$$u_{rms} = \sqrt{\frac{3\left(8.3145 \frac{J}{\cancel{K} \cdot \cancel{mol}}\right)(298 \cancel{K})}{4.00 \times 10^{-3} \frac{kg}{\cancel{mol}}}} = \sqrt{1.86 \times 10^{6} \frac{J}{kg}}$$

Since the units of J are $kg \cdot m^2/s^2$, this expression becomes

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-- Zumdahl, 5th Ed. p. 218

26

Chemistry?

Slide 27

1989 *NCTM Standards*

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- "**Manipulating symbols**"
- "Paper and pencil **fraction** computation",
- "Relying on **outside authority** (teacher or answer key)"
- "Rote **practice**"
- "Long division"

27

These standards
became the effective law by the year 2000
In every state except Massachusetts and California.
Is it a big surprise that your students are having
trouble solving calculations?

Bottom Line

"By 2000, all but 2 states (California and Massachusetts) … modeled their own curriculum standards on the NCTM's, and publishers revised math textbooks to conform with NCTM's prescriptions."

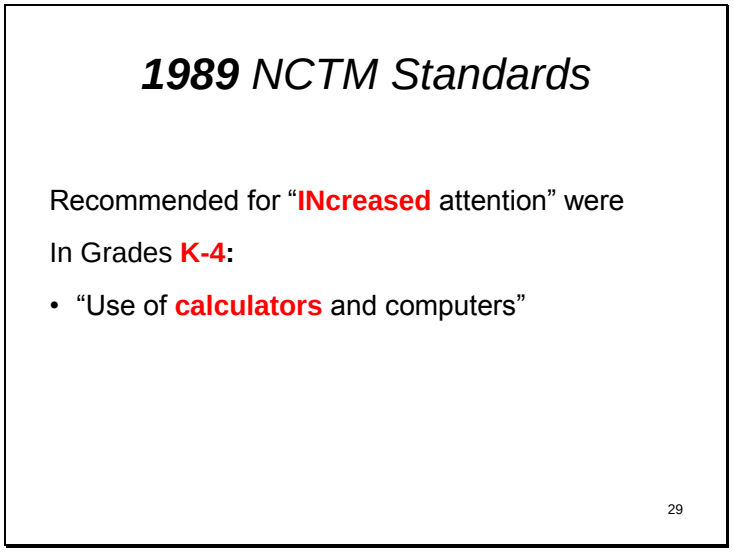
-- from

Computation Skills, Calculators, and Achievement Gaps:

An Analysis of NAEP Items

Tom Loveless, The Brookings Institution, April 2004

Slide 29



7:15
And I do mean required.
Take a look.

The NCTM recommended increasing the use of -- calculators -- in -- Kindergarten.

Slide 30

NJ: Use Calculators in 1st Grade

Q and A -- Core Standards in Mathematics
NJ State Board of Education – 1996 to 2010

Q: The standard says that students will "use calculators as problem-solving tools…." For what grade levels is this a reasonable expectation?

A: Calculators can and should be used at all grade levels …. The majority of questions on New Jersey's new third- and fourth-grade assessments in mathematics will assume student access to at least a four-function calculator.

-- http://www.state.nj.us/education/frameworks/math/math3.pdf
http://www.state.nj.us/education/genfo/overview/faq_cccs_math.htm

30

This is no joke.
Take a look at the orders to teachers
From the NJ Bd of Ed
in that last parg

This is not optional for teachers.
In K-12, what is tested on state tests had better get taught.

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To Balance:

$Pb(C_2H_5)_4 + O_2 \rightarrow PbO + CO_2 + H_2O$

use a calculator ?

31

My question for YOU is:
When students arrive in your class
And need a calculator to balance an equation,

How are they going to do in chemistry?

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1992: California Imposes NCTM Statewide

- In 1992, California adopted state-wide textbook adoption standards that followed the NCTM recommendations.

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California is an important exception.
If you teach in California, you may want to take a look at these slides.
Briefly:
California adopted NCTM in 1992.
Over the next 4 years, Student test scores collapsed.
California got out of NCTM by 2000.
And scores are going up.

Detail:
California is a “no local curriculum control – state control” state.
In 1992 California adopted NCTM-based standards and textbooks statewide.

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California Results:

- Went from ~30th of 50 states in 1992 to 49th on 1996 NAEP 4th grade scores -- ahead of only Mississippi.
- The percentage of entering CSU system freshmen failing an entry-level math test, leading to remedial courses, went from **23%** in 1989 to **54%** in 1997.

33

During the next 5 years, California test scores collapsed.

Slide 34

California Reverses Course:

Dec. 1997: The California Board of Education approves new standards written by four mathematicians at Stanford.

Opposing the 1997 Standards:
the *News Bulletin of the NCTM* (2/98) charged:

- "California's… curriculum standards emphasize basic skills and de-emphasize creative problem solving, procedural skills, and critical thinking."

In Favor: More than 100 California mathematics professors signed an open letter supporting the 1997 standards – including the chairs of the mathematics departments at Cal Tech and Stanford.

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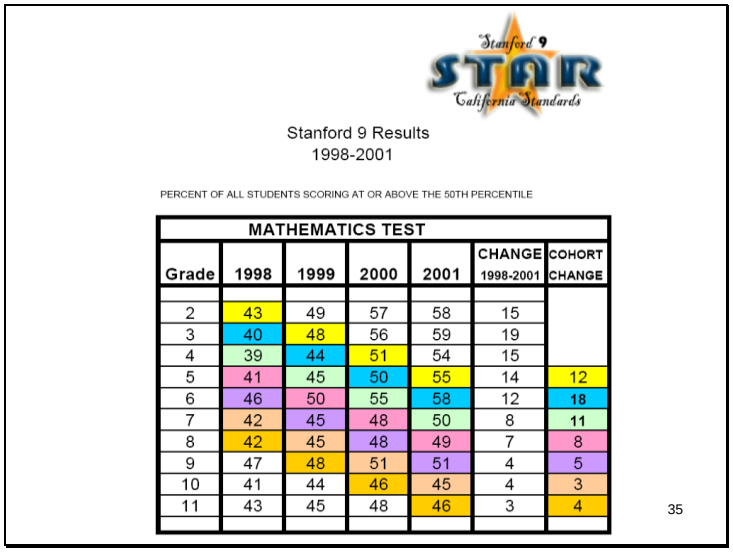
California then dumped the NCTM standards
(and returned to teaching basic skills)

Slide 35



Stanford 9 Results
1998-2001

PERCENT OF ALL STUDENTS SCORING AT OR ABOVE THE 50TH PERCENTILE

MATHEMATICS TEST						
Grade	1998	1999	2000	2001	CHANGE 1998-2001	COHORT CHANGE
2	43	49	57	58	15	
3	40	48	56	59	19	
4	39	44	51	54	15	
5	41	45	50	55	14	12
6	46	50	55	58	12	18
7	42	45	48	50	8	11
8	42	45	48	49	7	8
9	47	48	51	51	4	5
10	41	44	46	45	4	3
11	43	45	48	46	3	4

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And since then scores have gone up by every measure
But less so for children who were in school during the NCTM years.

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California Standards Test Results, 2003–2009
Mathematics
Table 5: Percentages of Students Scoring at Proficient and Above*

Grade	2003	2005	2007	2009	Change in Percentage 2003–2009
Grade 3	46	54	58	64	18
Grade 5	35	44	49	57	22
Grade 7	30	37	39	43	13
General Math	20	22	21	26	6
Algebra I†	21	19	24	28	7
Geometry	26	26	24	26	0
Algebra II	29	26	27	28	-1
Integrated 1	7	7	9	11	4

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But even in the fall of 2010, many students entering California colleges did not get much arithmetic back in K-3.
Those students are still behind where they should be.
But in 3 years, that problem will be in the past,
And California will be 10-15 years ahead of the rest of the nation.

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California Standards Test Results, 2003–2009 Mathematics

Table 6: Numbers of Students Tested*

Test	2003	2005	2007	2009	Change in Number 2003-2009
General Math	451,126	374,900	307,656	258,863	-192,263
Algebra I	505,883	681,924	744,814	758,139	252,256
Geometry	270,560	333,334	371,118	399,369	128,809
Algebra II	162,672	196,079	231,335	251,168	88,496
Integrated 1	14,359	8,716	7,071	9,962	-4,397
Total	1,500,936	1,696,192	1,776,274	1,806,685	305,749

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Enrollment in higher math is up quite a bit.

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California Science Scores

Science—End-of-Course Tests (Grades Nine Through Eleven)

Table 11: Percentages of Students Scoring at Proficient and Above*

Test	2003	2005	2007	2009	Change in Percentage 2003-2009
Earth Science	21	23	26	28	7
Biology	37	32	37	42	5
Chemistry	31	27	31	36	5
Physics	29	31	35	46	17

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In science scores are up a bit, and

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California Science Enrollment

Science—End-of-Course (Grades Nine Through Eleven)

Table 12: Numbers of Students Tested*

Test	2003	2005	2007	2009	Change in Number 2003-2009
Earth Science	89,676	173,958	207,246	226,111	136,435
Biology	334,005	453,685	507,155	534,877	200,872
Chemistry	153,491	196,700	227,866	247,306	93,815
Physics	44,878	59,382	63,450	67,838	22,960

39

Enrollment is way up
(but compare bio to chem and physics)

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Other States

Outside of California,

NCTM-type standards and textbooks adoption was more gradual, and

the changes were more gradual and often un-noticed (especially after national testing stopped), so

the NCTM standards and textbooks in most places remained in place.

40

By getting out by 2000, California has a 10-15 year lead over the 48 other states

In recovering from
letting students construct their own algorithms.

Slide 41

2002: Computation Data Stops

No Child Left Behind (NCLB, K-12)

- Required tests on *State* Standards
- Due to cost, most states stop nationally normed tests that separate “computation” from “total math.”

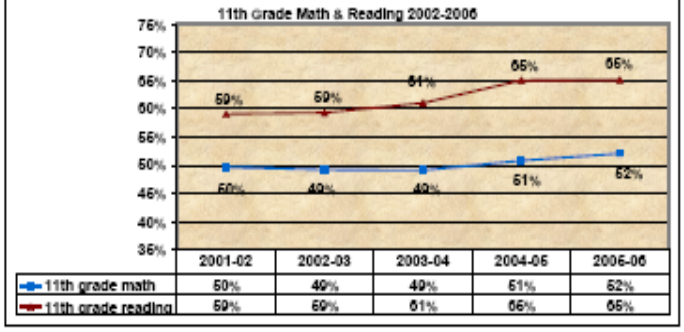
41

Why does the data stop in 2002 ? The answer is: NCLB.

No Child Left Behind required states to test on state standards,
And virtually every state then stopped
reporting math computation. Why?
On NCTM standards, computation is “de-emphasized.”
So why pay for tests to measure computation?

Slide 42

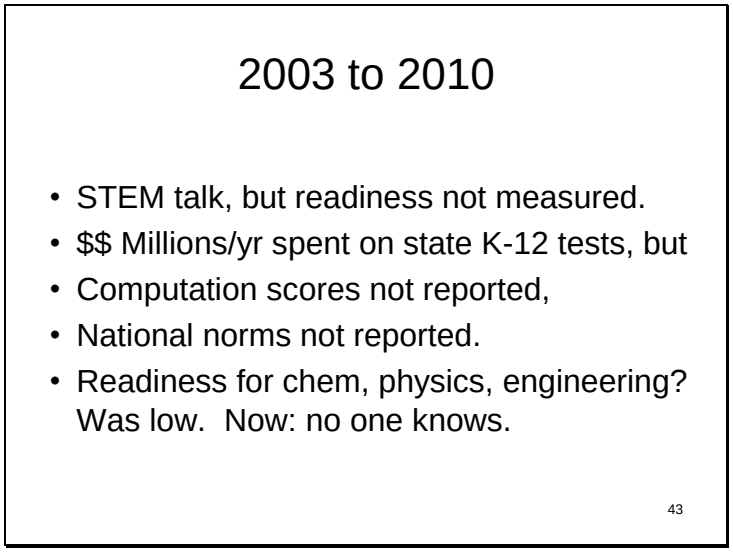
Pennsylvania:



42

Nearly all state test data is like this
that says 50-52% of students are “proficient in math in PA,”
But that tells you nothing about how state students compare
California, or China or India – the real competition.

Slide 43



Readiness for STEM courses is talked about,
And every state is spending millions of dollars every year on testing.

But, for the past 8 years, nearly every state has decided not to report test results on the skills needed
For chemistry, physics, and engineering.

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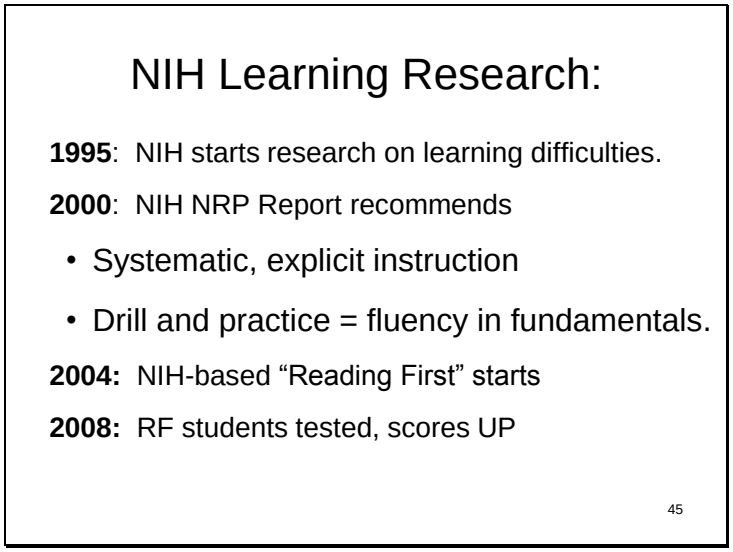
But there is some good news.

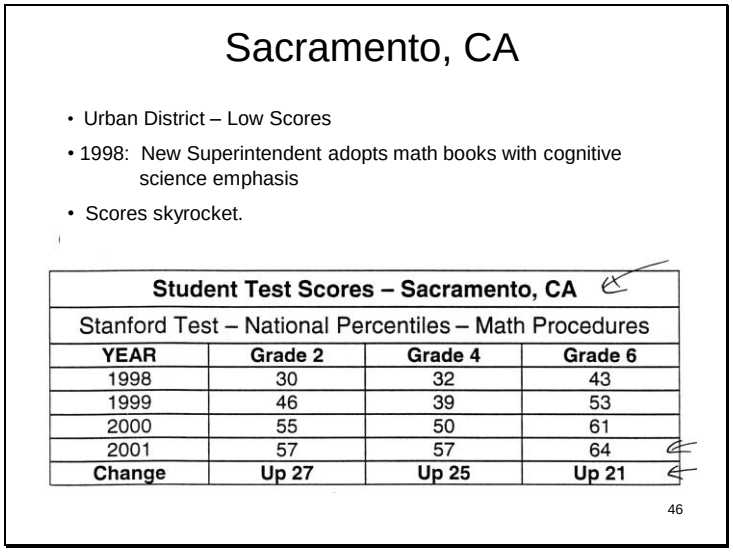
Slide 45



In 1995, the NIH began to study how the brain works and how students learn.

That research laid the foundation for the new "**cognitive science**,"
And where cognitive science has been applied to instruction,
the results have been impressive.

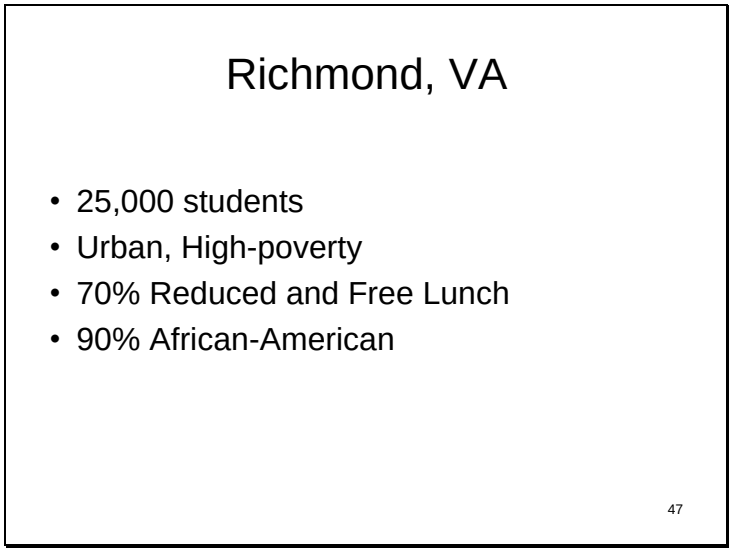
Slide 46



In 1998, Sacramento, a high poverty urban district. Adopted a cognitive-science-based math program.

Look at those gains in computation – just from using science-based textbooks.

Slide 47



Richmond VA is another
urban, high poverty district.

In 2001, Richmond started using a new curriculum
based on cognitive science

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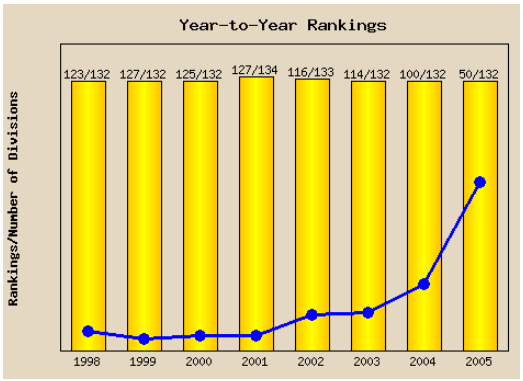
Between 2001 and 2005, in 3rd Grade Reading, for *all* students, Richmond VA rose from ranking in the bottom 5% to the top 40% of the state, an unprecedented accomplishment for a high-poverty district.



48

And in reading, Richmond students went
(from ranking 123 out of the 132 districts in the state to 50th of 132)
From bottom 5% of the state, typical for urban districts, to the top 40% --in just 4 years.

Those are unprecedented urban scores.
All it took was the adoption of science-based textbooks
And training to help teachers apply the new research about how the brain works.

If high-poverty Richmond can achieve those gains,
How much could we increase the number of students earning STEM degrees
If we did what Richmond did , and adopted instruction based on cognitive-science
Across our math and science curriculum?

Slide 49

The Two Philosophies:

Traditionalists/Behaviorists believed in

- Drill and Practice, Memorization of Facts
- "Learning is Hard Work"

Progressives/Constructivists/NCTM believed

- Learn Naturally, By Discovery
- Don't "Drill and Kill"; Don't Memorize

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Many of you are familiar with the recent cognitive research.
Let me tell you what I think it says to science educators.
The research addresses the 200-year-old debate
In education over behaviorism vs. constructivism:
drill and practice versus discovery.

And the science says, you need parts of BOTH.

Slide 50

NIH /Cognitive Science findings:

Constructivists were right on:

- Discovery & Inquiry Motivate Students
- Concepts are Crucial for Memory
- Must construct conceptual framework
- Speech is learned naturally -- to age ~12

However:

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The science says that constructivism
got many things right.

My own heros and heroines in chemistry are the constructivists
Who have done so much good work to motivate students to want to learn science.
Without that, none of the rest of this matters.
BUT

Slide 51

Memorization? Necessary.

"Data from the last 30 years lead to a conclusion that is not scientifically challengeable:

thinking well requires knowing facts….

Critical thinking processes like reasoning and problem solving are intimately intertwined with factual knowledge that is in long-term **memory** (not just in the environment).

***** Building expertise actually changes the thought process, but such change takes many years of advanced study."

-- Daniel Willingham

http://archive.aft.org/pubs-reports/american_educator/issues/spring2009/index.htm

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Here's the bad news:
Take a look at this slide – this is what the science says.

Nobody likes to hear this, but:
To become a good problem solver takes memorization:
repeated practice of facts and algorithms
That are the core knowledge in a discipline

To solve problems, you must have CONCEPTS -- PLUS facts PLUS algorithms
In your long-term memory.

Slide 52

NIH/Cognitive Science findings:

- Except for speech, learning is hard work.

Solving problems requires

- Extensive Knowledge In LT **Memory** +
- **Fluency**: Automatic recall of fundamentals

-- *NRP Report*, NIH (2000), Willingham, *Cognition* (2004)

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The science says learning is hard work.
The way you learned chemistry is the only way that works.
Solving problems requires fluency:
Fast automatic recall of fundamentals.

Because of limitations on working memory, students nearly always must solve problems using …. Using…??
Here's a hint:

Slide 53

53

?...
algorithms.

Science does say that the role models for our students should be people who
Are famous for their work ethic, people who practice

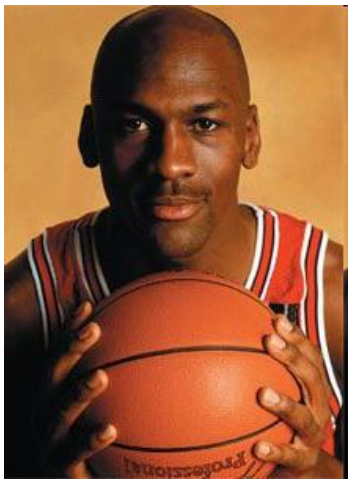
Slide 54

54

drill

Lindsay Vonn

Slide 55



And

mj

Slide 56

practice

That’s the science.

Joshua Bell

Slide 57

In Chemistry

Don Dahm at Rowan University used cognitive-science-based homework to

- Reduce required lecture time and
- Increase lab time

While maintaining high achievement.

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I've been working on a project with
Don Dahm at Rowan University to apply cognitive science to chemistry.

(Our goal is to have students practice computation as homework before lecture
so that lecture on math is reduced, and more time is available for concepts and labs.)

Slide 58

Given an Engineering Chem schedule of

- 75% of std. GenChem lecture time and only 25% of std. GenChem Lab time,

By using cog sci-based homework, Don was able to change to

- 50% GenChem Lecture time and 50% Lab

Then he gave the *ACS General Chemistry 2 Semester Exam*. Students scored at the

58

At Rowan, the schedule allowed most of the engineers to have only one semester of chemistry.

Starting from a schedule that had 75%....

With 50% less lecture,
How well would students do on the 2 semester ACS exam?

The ACS median is the 50th percentile; Don's students scored at the

Slide 59

63rd ACS Percentile

- In part by assigning computation lessons as homework prep for lecture.
- Details on his model (plus all assignments): Search "ACS ChED CCCE Newsletter" Or
- http://ched-ccce.org/newsletter/Pages_NewsF09/F2009_News.html

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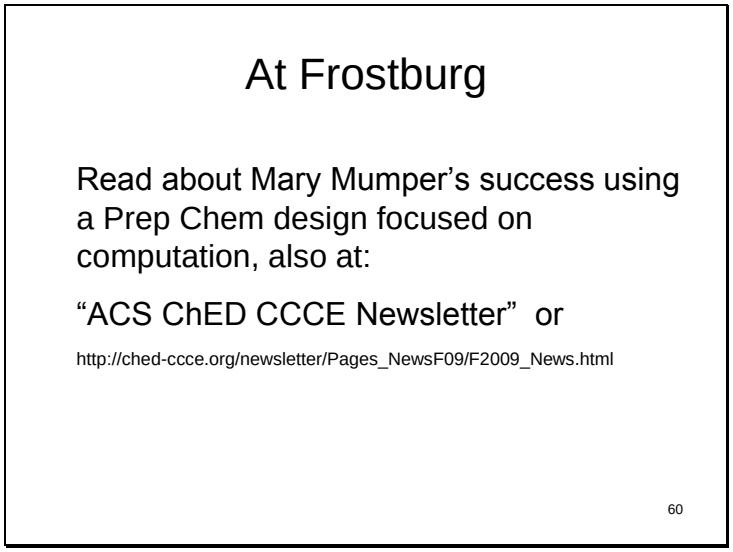
the 63rd ACS percentile, and Don doubled the time available for labs.

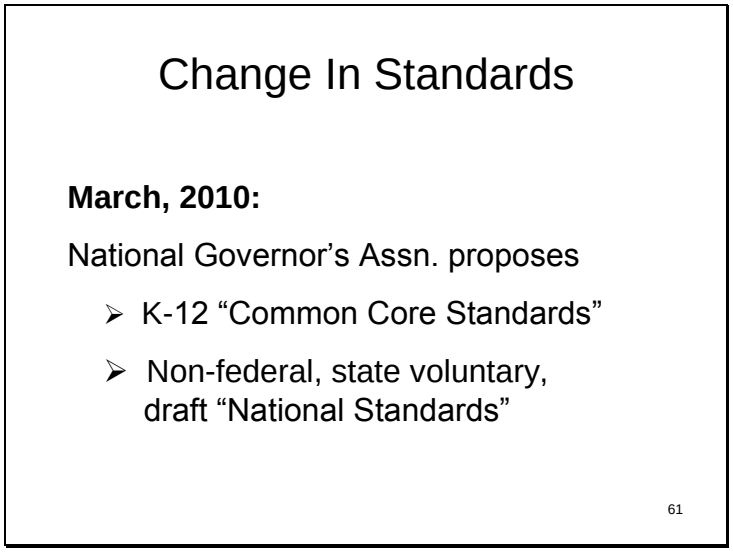
In the crisis that is about to be upon us, IF you are forced
to cut your budget for first-year instruction,
And you want to save lab time and achievement,
You might want to take a look at the "hybrid" design that Don developed.

Slide 60



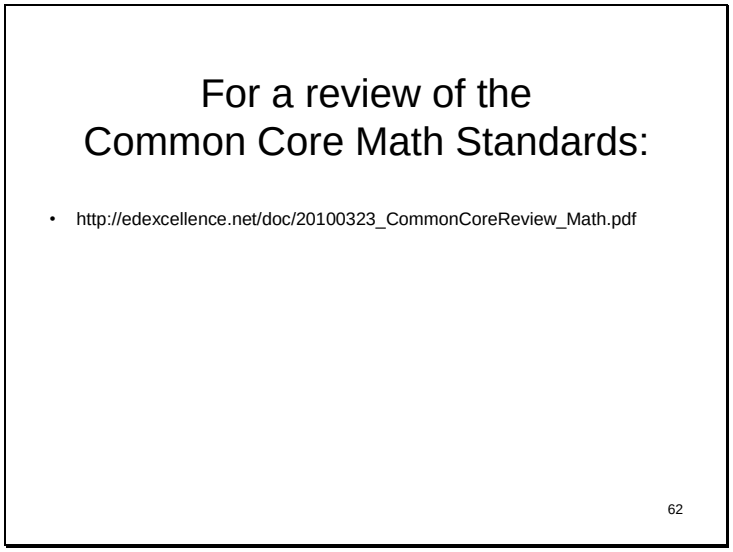
In Prep Chem, at Frostburg, Mary Mumper has also used the same lessons as Don and she was very happy with the results, which you can read about here.

Slide 61



n1340
Finally, in 2010,
A new set of national math standards has been proposed.
Over half the states have already agreed to adopt them.

Slide 62



The standards are here.

Slide 63

Common Core Standards:

Good on Computation:

- "Fluently add and subtract within 20." (Grade 2)
- "Fluently … multiply whole numbers using the standard algorithm…." (Grade 5)

(Fluent means: fast from memory.)

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They are based on cognitive science – see *fluency* ?
And they are very good.
But don't be fooled.

Standards do not determine what is taught.
In K-12, it is the subjects with scores that are posted on the internet that get taught.

But Standards Don't Fix

To Get Students Prepared for STEM:

- Computation must be reported separately from "total math."

What is tested is taught.

64

The math needed for chemistry will be taught
IF and ONLY IF
computation is a posted score in your state.

Let's Summarize.

Slide 65

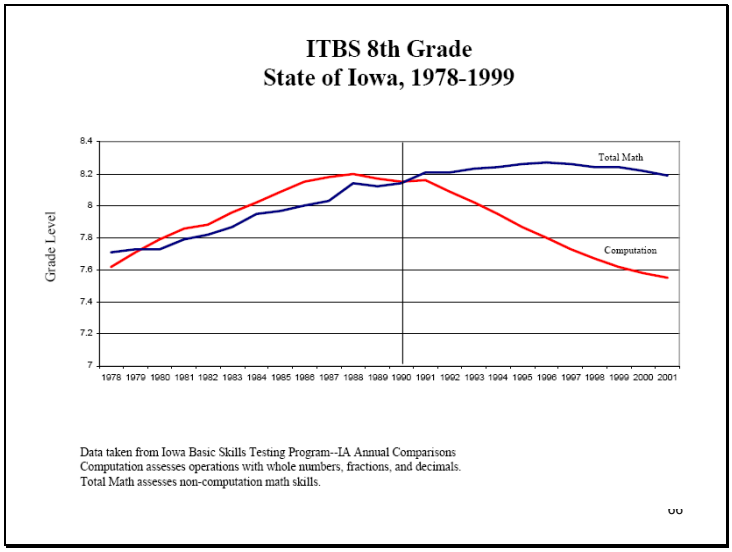
Virginia Math Test Scores

VA Stanford 9	Grade 9				
	1998	1999	2000	2001	**2002**
Total Math	54	55	55	55	55
Problem Solving	**58**	61	63	64	**65**
Procedures	**46**	44	42	41	**39**

65

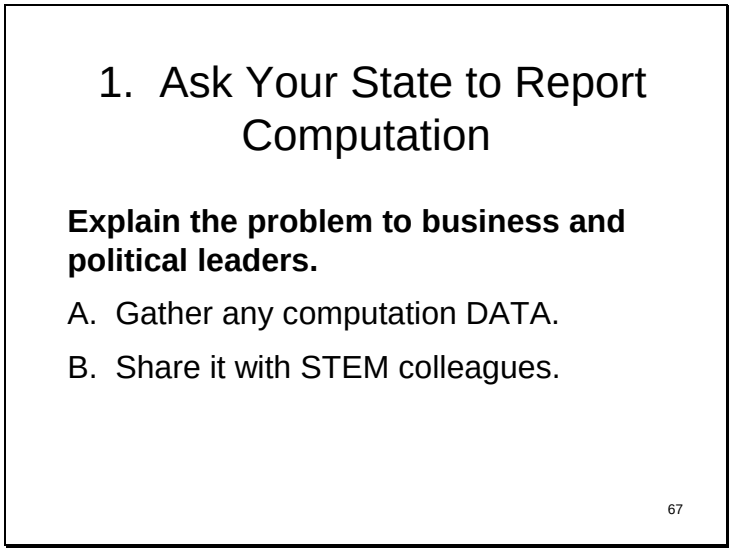
Today, we have identified a problem.
You voted that poor student computation skills were a major problem in chem instruction,
And the data confirmed the problem.

Slide 66



We've identified the reason for the problem: states told teachers to stop teaching computation
And states stopped testing computation.
(When students were taught to solve calculations, they were getting better.
When states told teachers to stop teaching computation, students got worse.)
This has been going on for 20 years,
But it can be fixed.

Slide 67



Let me suggest this three point plan.

To begin, explain the problem to your state's decision-makers.

You understand the importance of computation.
No one else does.

C. Decide Goals. Consider:

- Report computation
- Include chemists, physicists, and engineers when deciding *computation* standards.
- Limit calculators on tests
- Measure versus international norms
- Test readiness for college and work
- High test security and reliability

Slide 69

The Key

D. Take DATA to tech **business** leaders. Ask support. You'll get it.

E. Take **business** leaders to ask **political** leaders for support.

Slide 70

Results

- **You will win.**
- **Over 5-15 years = better prepared students.**

70

You will win
But students who have not been taught fundamentals,
It will have take years to get them to where they should be.

Slide 71

2. Use Cog Sci to remediate

During the wait, triage:

- Use cognitive science to improve computation using homework, prep chem.

(see Don and Mary's experiments).

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So, while you are waiting for better preparation,
Use cognitive science to offer remediation to those who can be helped.

Slide 72

3. Apply Cognitive Science to Instruction:

- **In class:** Motivation and Concepts
- **Homework:** Facts, Algorithms, Practice

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- Experiment -- read about cognitive science, and apply it in your classes.

For homework, find a book that students can read that teaches and reviews background knowledge. Set deadlines -- and quiz.

Slide 73

VA Stanford 9	Grade 9				
	1998	1999	2000	2001	**2002**
Total Math	54	55	55	55	55
Problem Solving	**58**	61	63	64	**65**
Procedures	**46**	44	42	41	**39**

39th percentile → America in decline

BUT IF we apply cognitive science,

73

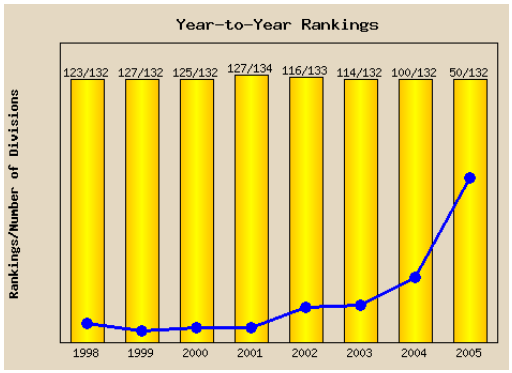
So, we have shown a solution: you, who understand the problem,
Ask your states to test on computation. And I hope you will do this.
Because this is not just a problem in chemistry.

Science is the foundation for a competitive national economy.
If we do not address this problem, it guarantees crisis after crisis
In funding for education, for our pension plans, and for our nation.

But if we apply cognitive science to instruction,
Achievement does

Slide 74

Achievement Does This:



74

this.

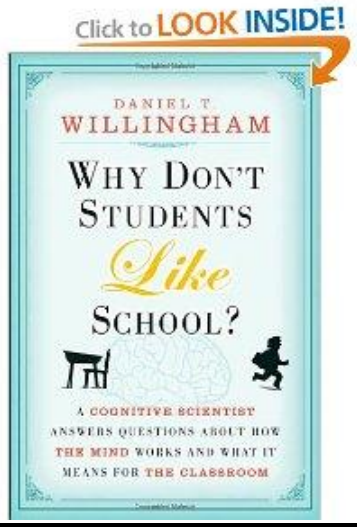
The world needs for democratic values that America stands for to prosper and prevail.

You can have a key role in making that happen.

Slide 75

3 Books on the New Cognitive Science:

1. Easy Read

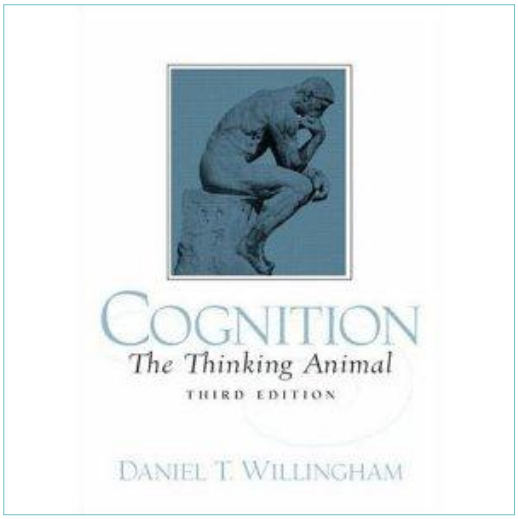


To learn more
about the new cognitive science,
here are 3 books.

This is Easy

Slide 76

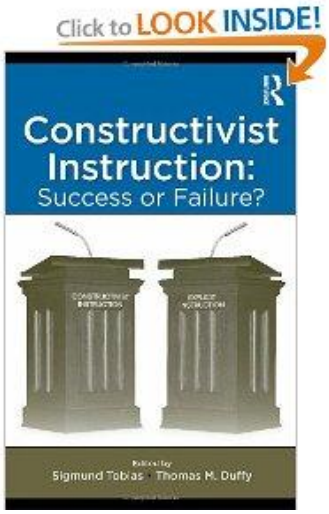
2.
Cog
Psych
Textbook



A textbook

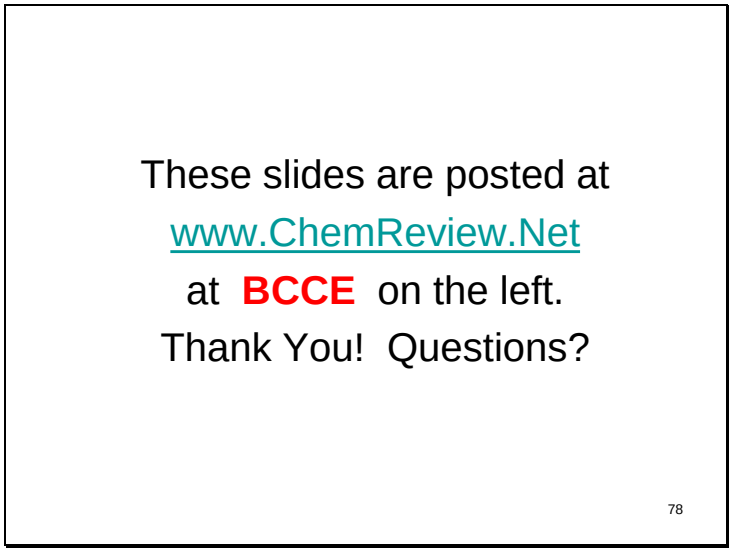
Slide 77

3. Cutting Edge on Theory



and psychobabble, but very good.

Slide 78



Thank you for your patience.
These slides are posted here.
Please feel free to put them to good use.