Slide 1

"Common core" standards,
student test scores
in math computation,
and the implications for
chemistry instruction

Presented 7/28/2012 to the
Math in Chemistry symposium at BCCE
By Rick Nelson, Retired Instructor
EANelson@ChemReview.Net

1

Good afternoon.
Let me start with an apology. I am going to go a bit too fast. But I will put up a web address at the end
where you may view the any slides of interest at your leisure.

I am going to restrict my talk today to the question of: "How can we help students solve the type of
calculations
That we assign them in general chemistry?"

Slide 2

Vote for ONE:

To start **Gen** Chem, it is *most* important
that students have background in

A. Use of a Calculator
B. The Theory of Math
C. Math Computation

2

I'd like to ask you to read and be ready to vote on this.

Slide 3

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

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

$$= 1.76 - \frac{0.0591}{2} \log\left(\frac{(1.0 \times 10^{-1})(1.0 \times 10^{-2})^2}{(2.0)^2(0.50)^4}\right)$$

$$= 1.76 - \frac{0.0591}{2} \log(4 \times 10^{-5}) = 1.76 + 0.13 = 1.89 \text{ V}$$

-- Zumdahl, 5th edition

3

In Gen Chem, we ask students to solve problems like this

Slide 4

Thus

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

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

4

And this…

Slide 5

Vote for ONE:

To start **Gen** Chem, it is *most* important that students have background in

   A. Use of a Calculator
   B. The Theory of Math
   C. Math Computation

In **chem**, which ONE is MOST important?

5

All of these are important but in
chemistry, if you had to pick ONE, which is most important?
How many vote for   A: _____   B: _____ C: _____

(The vote was about 95% for math computation).

For ~10$^+$ year faculty:

(Vote for ONE:)

Since 2002, I have seen the **computation skills** of first-year students:

  A. Improve substantially
  B. Improve
  C. Not change
  D. Decline
  E. Decline substantially

6

Now I have a special question for faculty who have taught for more than 10 years. Please read and be ready to move those creaky fossilized joints to vote

for A : _____   B : _____C : _____ D : _____ E : _____

The average is between? (D and E received by far the most votes.)
OK. Thank you for the data.

The
"Monty Python Group"
Experiments

7

For the past 5 years, I've been working on experiments with a small team of instructors, and our goal is to improve student achievement and retention in first-year Chem, and because that's the Holy Grail, we call ourselves…..

Dahm: Rowan Engineering Chem
(2 sem. Gen Chem in 1 sem.)

2006

ACS Exam:
 (not given)

Lab Periods:
 10 for Lab
 5 for Lecture

8

This started at Rowan University in NJ. My buddy Don Dahm was teaching engineering chemistry, which at Rowan is two semesters of Gen Chem on a one semester schedule, and Don was having to lecture during 5 of his 15 lab periods to cram all the content in. So Don was not happy.

Dahm's "Calcs In Chem" Expt.

1. **Homework:** *Review* **Math** for Topic

   Learn Chem Facts

   Practice Problem Solving

2. **Lecture:** Active learning of *concepts*

3. **Quizzes:** Weekly

9

So we decided to try an experiment: to write tutorials that moved a *part* of the lecture into homework, so there would be more time during lab and lecture for *active learning*.

We included a review of the math needed for each topic
and a weekly quiz to "encourage" students to keep up with the homework.

Dahm: Rowan Engineering Chem
(2 sem. Gen Chem in 1 sem.)

2006   **2008**

ACS Exam   ACS Exam
? pctl.   **63**rd pctl.

→

Lab Pds: Lab Periods:
10 for Lab   **15** for Lab
5 for Lecture

10

And after two years of trial and lots of errors, scores on the ACS Gen Chem Final Exam for Don's students were at the 63th percentile. (which we thought was not bad for Gen Chem in one semester).
Best of all, Don was able to go from 10 labs to the full 15.
(By 2011, the ACS percentile was 64, and Don had about 20% fewer drops.)
And Don is happy. He's doing more chemistry.

Slide 11

Use of "Calculations in Chemistry"
In Prep Chem at Frostburg:

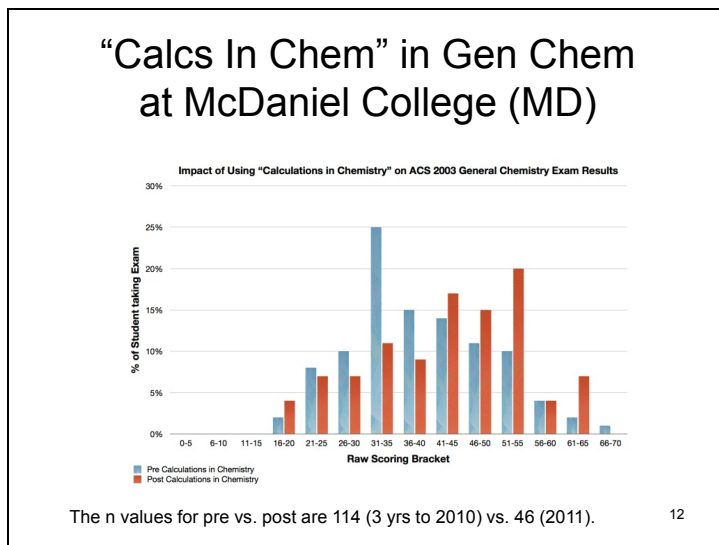• 70% of Prep Chem enrolled in Gen Chem

• 75% of those passed first semester.

"My belief is that we rescued many of these students from failing General Chemistry."

-- Dr. Mary Mumper
Paper #4 -- 11/2009 Newsletter
CCCE/DivCHED/ACS

11

At Frostburg State in Maryland, Dr. Mary Mumper adopted a portion of Don's homework tutorials as the textbook for a new course Prep Chem.

Over the first 3 experiment semesters, 70% from Prep Chem enrolled in General Chemistry, and 75% Of those passed first semester. This is what Dr. Mumper wrote in her report to faculty.

Slide 12

"Calcs In Chem" in Gen Chem at McDaniel College (MD)

Impact of Using "Calculations in Chemistry" on ACS 2003 General Chemistry Exam Results

The n values for pre vs. post are 114 (3 yrs to 2010) vs. 46 (2011).

In 2010 at McDaniel College, Dr. Peter Craig used Don's tutorials for homework assignments in General Chemistry. Each year, Dr. Craig uses ACS exam as his final.

The x-axis has the ACS score ranges. The blue bars are the distribution of the scores for the 3 years *before* Dr. Craig used the lessons. The red bars are the scores for the year that he used the lessons. Blue before, red after. The rise in median score is from about the 45th to about the 60th percentile.

Unnamed - All Undergraduates (IRB)

<u>General Chemistry -- First Semester Common Exam Grades</u>:
- About 50 Sections Total
- In 2 sections, "Calcs In Chem homework" assigned to students needing extra help; suggested to others.
- On exam, those 2 sections had 47% more A's and 72% fewer F's

	A	B	C	D	F
Exam distribution - all (n ≈ 1,000)	10%	24%	34%	21%	11%
"Calculations" hmwk assigned, suggested (n ≈ 36)	14.7%	23.5%	35.3%	23.5%	2.9%

13

Finally, last year at a school where there was a concern about the IRB paperwork: 1000 students in Gen Chem took the first semester common exam, and in the small sample that had used Don's online homework lessons, there were 47% more A's and 72% fewer F's.

Those are the Monty Python results so far.

As part of our lessons, we *teach* quite a bit of math. Let me explain why we think we need to teach math in chemistry.

Virginia Math Results:

- Stanford 9 standardized test given statewide
- 1995: normed at 50th percentile

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

14

I got involved in the "math and chemistry" issue about 8 years ago,
when I was working for my faculty organization on a task force looking at
why so many Virginia students entering college needed remediation in math.

When we looked at the test scores for students, in "Total Math," Virginia scores were
above national average – the 50th percentile -- and steady.   But to me, those scores
didn't look right. So I looked in the back of the report,

Two **sub**tests were reported described as

- **"**Math Problem Solving, which focuses on reasoning skills, and

- Math Procedures, which measures the student's facility with computation."

15

and I found that on the test VA was using, "Total Math" was actually a composite of two **sub**tests: one on math *reasoning* and the other on math *computation*

Slide 16

Virginia Math Scores

All students	Grade 9				
	1998	1999	2000	2001	2002
Total Math	54	55	55	55	55
Problem Solving (Reasoning)	58	61	63	64	65
Procedures (Computation)	46	44	42	41	**39**

--Virginia State Assessment Program, Detailed Report
Stanford Achievement Test Series, Ninth Edition (*Stanford 9*)
Statewide Percentile Ranks
2002 Fall Results, Appendix Table 2

16

Here's that data -- from 80,000 students/year in 130 independent districts.
In math **reasoning**, scores were way above the 50th percentile and getting higher every year.

But in **computation**, the math that's important in chemistry, scores were low and getting lower every year.

Virginia Math Scores

All students	Grade 9				
	1998	1999	2000	2001	2002
Total Math	54	55	55	55	55
Problem Solving (Reasoning)	58	61	63	64	65
Procedures (Computation)	46	44	42	41	**39**

--Virginia State Assessment Program, Detailed Report
Stanford Achievement Test Series, Ninth Edition (*Stanford 9*)
Statewide Percentile Ranks
2002 Fall Results, Appendix Table 2

17

This raised two questions. One: When your state average in computation is at the 39th percentile, what percentage of these students are going to be ready for the rigor and pace of college chemistry?

Two: Getting a lot better at reasoning in math, but getting a lot worse at solving calculations – no transfer --   Is that what you'd expect?

When the math issue came up several months later at a chemistry meeting in New Jersey, Don and I went looking for data in other states.
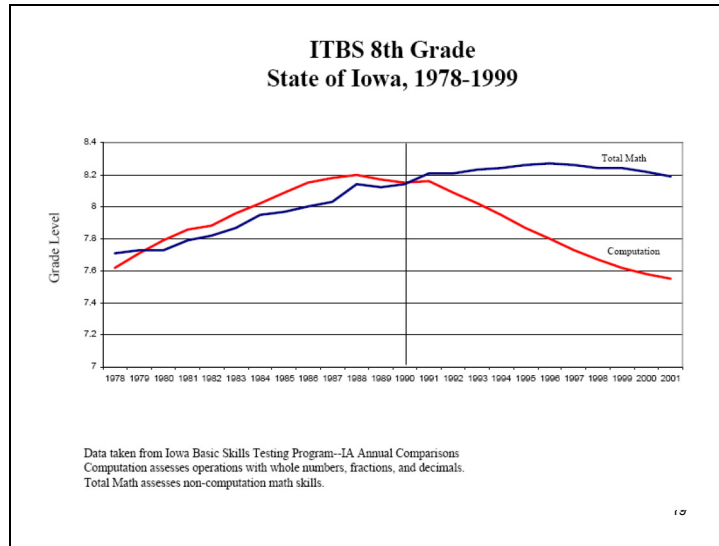
Next three graphs from:

Dr. Tom Loveless, Director

Brown Center on Education Policy
at the Brookings Institution

Presentation on Math Reform
at AEI, March 4, 2002

http://www.aei.org/files/2002/03/04/20030326_loveless.pdf

18

This report was found online from Tom Loveless at the Brookings Institution.
Dr. Loveless said the best data was for the state of

Slide 19

Iowa. In Iowa, like Virginia, each K-12 district does its own textbook adoption
So you get a random sample of curricula nationally, but Iowa gave the same test for over 20 years.
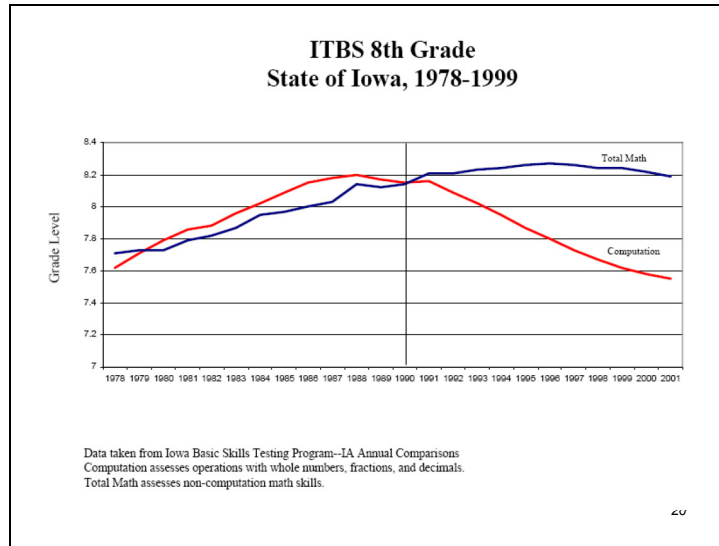
This graph starts in 1978 and goes to 2001.

Do you see a problem?   What is it?   When does the problem start?

Out here at the right: does total math hide the computation problem?   Just like in Virginia?
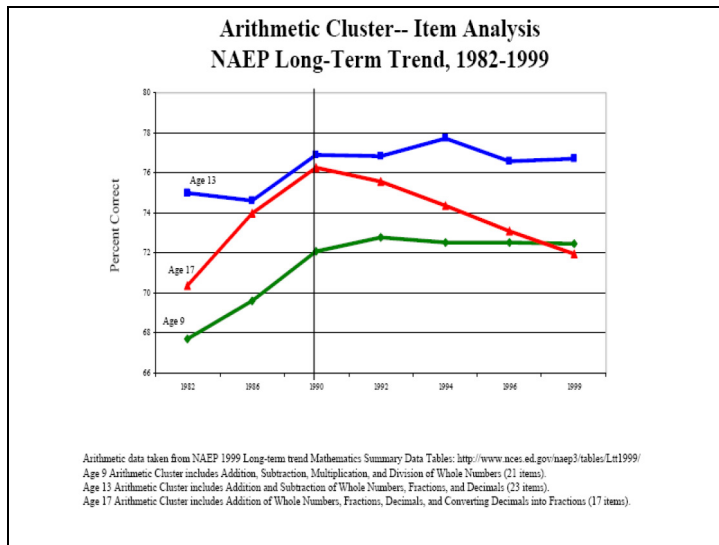
Note from 98 to 01 – these results are convergent with Virginia: Total math flat; computation low and going lower.

Slide 20

ITBS 8th Grade
State of Iowa, 1978-1999

Data taken from Iowa Basic Skills Testing Program--IA Annual Comparisons
Computation assesses operations with whole numbers, fractions, and decimals.
Total Math assesses non-computation math skills.

Note also that something is missing. Total math is a composite. What Dr. Loveless did not graph (his focus was computation) are the "concepts" and "reasoning" subtests on the ITBS. In Iowa, reasoning and concepts went up, but that did not help with the math needed for chemistry.

Arithmetic Cluster-- Item Analysis
NAEP Long-Term Trend, 1982-1999

Arithmetic data taken from NAEP 1999 Long-term trend Mathematics Summary Data Tables: http://www.nces.ed.gov/naep3/tables/Ltt1999/
Age 9 Arithmetic Cluster includes Addition, Subtraction, Multiplication, and Division of Whole Numbers (21 items).
Age 13 Arithmetic Cluster includes Addition and Subtraction of Whole Numbers, Fractions, and Decimals (23 items).
Age 17 Arithmetic Cluster includes Addition of Whole Numbers, Fractions, Decimals, and Converting Decimals into Fractions (17 items).
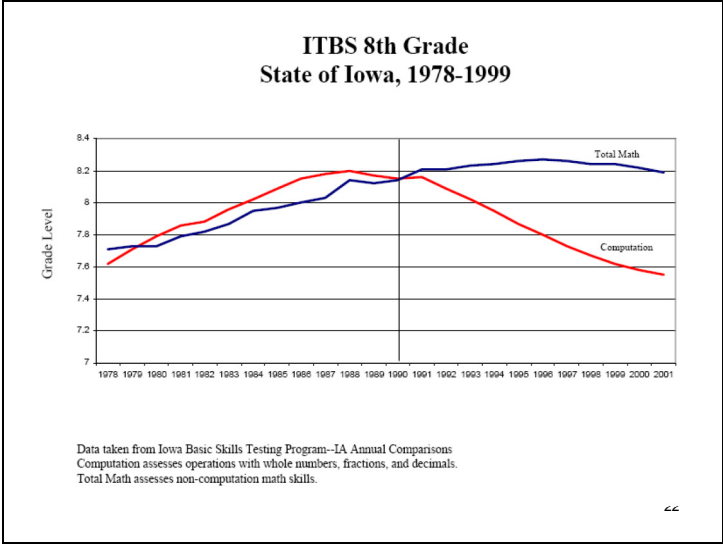
Dr. Loveless also looked at a **nation-wide** measure: The National Assessment of Educational Progress (NAEP -- the "nape") the "nation's report card," given every two years in every state.

In the **arithmetic** that we do quite a bit of in chemistry, the RED line is for the 17 year olds that we are most concerned with.

For the 17-year-olds in red, when is it GOOD?   When is it BAD?

Slide 22

ITBS 8th Grade
State of Iowa, 1978-1999

Data taken from Iowa Basic Skills Testing Program--IA Annual Comparisons
Computation assesses operations with whole numbers, fractions, and decimals.
Total Math assesses non-computation math skills.

Like computation in Iowa?

Slide 23

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

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

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

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

23

In chemistry, we need students to solve some complex fractions.
Here we have a fraction times a fraction over a fraction.

Slide 24

Thus

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

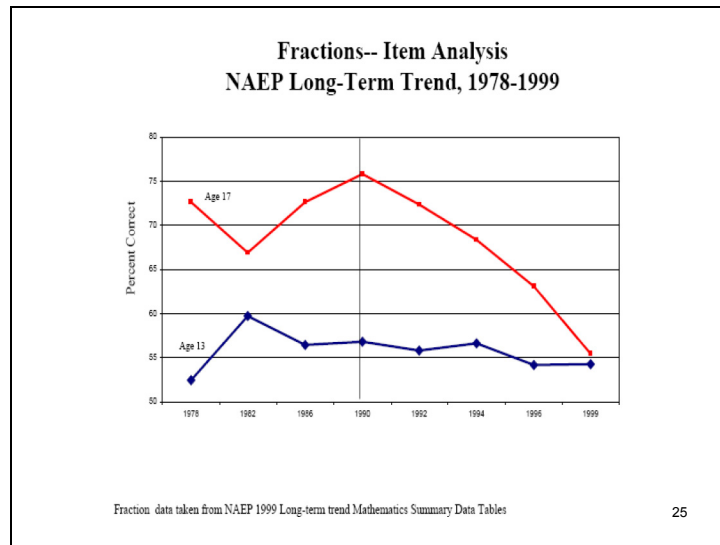Since the units of J are $kg \cdot m^2/s^2$, this expression becomes

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

-- Zumdahl, 5th Ed. p. 218

24

And the top fraction here involves 3 fractions.

Slide 25

Fractions-- Item Analysis
NAEP Long-Term Trend, 1978-1999

Fraction data taken from NAEP 1999 Long-term trend Mathematics Summary Data Tables

Dr. Loveless looked at fractions on the NAEP and found, for the 17 year olds, fluctuation before 1990, then a dramatic decline From **24%** wrong in 1990 to **44%** wrong in 1999, nationwide.

When their fundamental background in fractions is down here,
What's happens when these students get to

Slide 26

Thus

$$u_{\mathrm{rms}} = \sqrt{\dfrac{3\left(8.3145\ \dfrac{J}{K \cdot mol}\right)(298\ K)}{4.00 \times 10^{-3}\ \dfrac{kg}{mol}}} = \sqrt{1.86 \times 10^6\ \dfrac{J}{kg}}$$
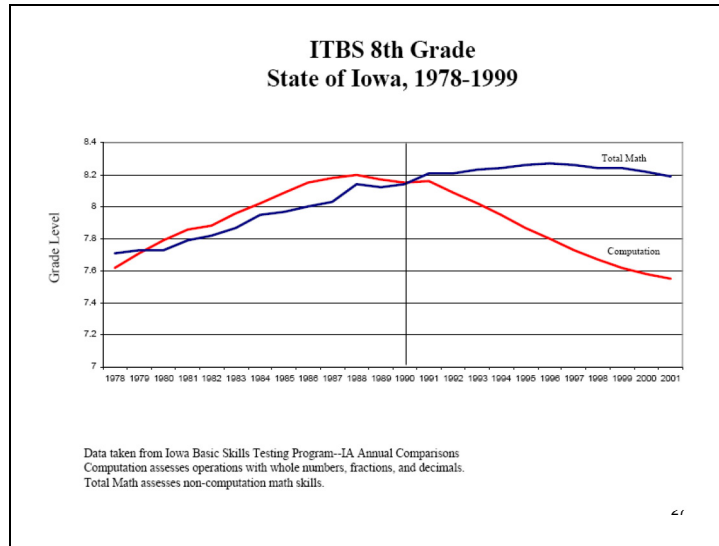
Since the units of J are $kg \cdot m^2/s^2$, this expression becomes

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

-- Zumdahl, 5th Ed. p. 218

26

Chemistry?

Slide 27

ITBS 8th Grade
State of Iowa, 1978-1999

Data taken from Iowa Basic Skills Testing Program--IA Annual Comparisons
Computation assesses operations with whole numbers, fractions, and decimals.
Total Math assesses non-computation math skills.

There's more data, but it's all convergent. By all the measures we have, after 1990, across the nation, scores in the math we need in chemistry collapsed, but it went largely un-noted because it was hidden by "total math."

Vote for one:

Given the nature and magnitude of these data, how serious a problem is *computation background* for students needing to learn Gen Chem (in about 2003) ?

   A. Not very serious

   B. Serious

   C. Very Serious

28

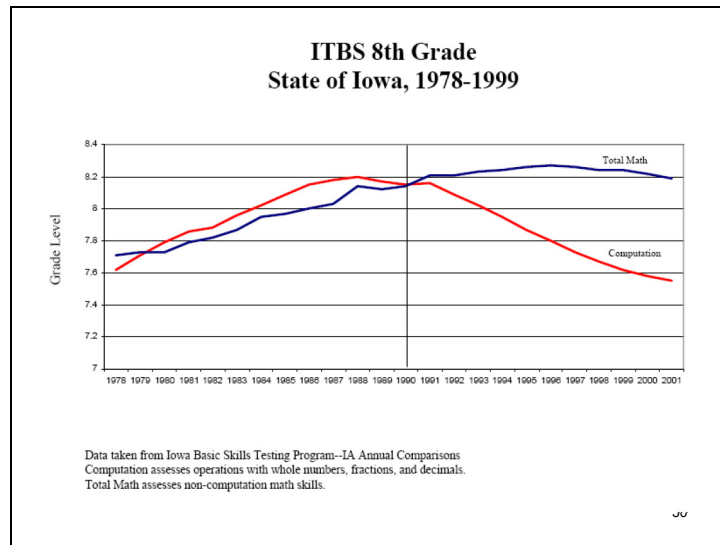How serious is this? Let me let you decide. Please take a moment to read this slide, And then we'll vote.

Slide 29

Virginia Math Scores

All students	Grade 9				
	1998	1999	2000	2001	2002
Total Math	54	55	55	55	55
Problem Solving (Reasoning)	58	61	63	64	65
Procedures (Computation)	46	44	42	41	**39**

--Virginia State Assessment Program, Detailed Report
Stanford Achievement Test Series, Ninth Edition (*Stanford 9*)
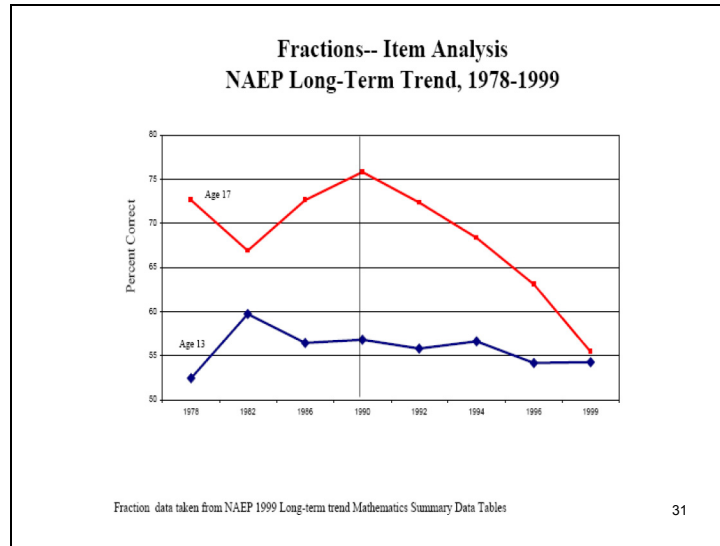Statewide Percentile Ranks
2002 Fall Results, Appendix Table 2

29

Virginia

Slide 30

**ITBS 8th Grade
State of Iowa, 1978-1999**

Data taken from Iowa Basic Skills Testing Program--IA Annual Comparisons
Computation assesses operations with whole numbers, fractions, and decimals.
Total Math assesses non-computation math skills.

Iowa

Slide 31

Fractions-- Item Analysis
NAEP Long-Term Trend, 1978-1999

NAEP,

Vote for one:

Given the nature and magnitude of these data, how serious a problem is *computation background* for students needing to learn Gen Chem (in about 2003)?

A. Not very serious

B. Serious

C. Very Serious

32

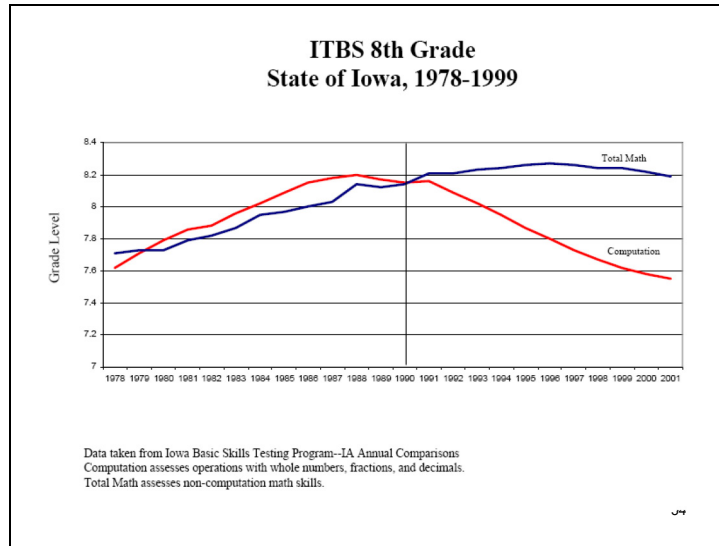What's your view? How many vote for A? B? C?   The average is: (was 95% C).

Has this been interesting data -- so far?

Why no state computation scores since 2002?

33

Let's get up to date. You may have noticed that all of my state data stops in 2002. Why?

Slide 34

ITBS 8th Grade
State of Iowa, 1978-1999

Data taken from Iowa Basic Skills Testing Program--IA Annual Comparisons
Computation assesses operations with whole numbers, fractions, and decimals.
Total Math assesses non-computation math skills.

2001.

Slide 35

Virginia Math Scores

All students	Grade 9				
	1998	1999	2000	2001	2002
Total Math	54	55	55	55	55
Problem Solving (Reasoning)	58	61	63	64	65
Procedures (Computation)	46	44	42	41	**39**

--Virginia State Assessment Program, Detailed Report
Stanford Achievement Test Series, Ninth Edition (*Stanford 9*)
Statewide Percentile Ranks
2002 Fall Results, Appendix Table 2

35

2002.   What happened in 2002?   AP folks?

2002: NCLB
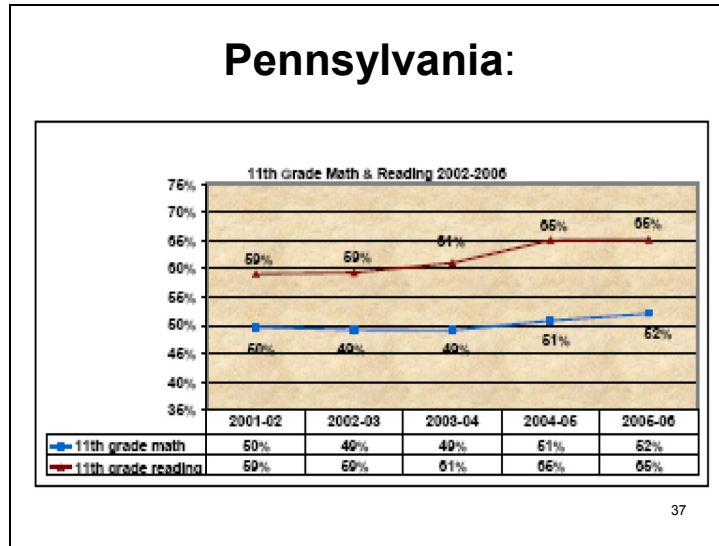
Mandates Tests on State Standards.

High test prep costs = most states
   stop *nationally normed* tests.

Since 2002: $$$$ reporting "total math"

But NO state reports *computation*.

36

No Child Left Behind required each state to pay for a test customized to their own state standards. And, perhaps since adding a subtest is expensive, no state that I can find, and I've looked, has given a test that measured **computation** since 2002.

Slide 37

Pennsylvania:

11th Grade Math & Reading 2002-2006

	2001-02	2002-03	2003-04	2004-05	2006-06
11th grade math	50%	49%	49%	51%	52%
11th grade reading	59%	59%	61%	65%	65%

37

States do report "proficiency in total math" versus state standards. But that's the wrong variable. They want STEM majors, but they are not measuring preparation for STEM. And: how are these kids are doing versus the national average? Or versus China and India – the real economic competition?
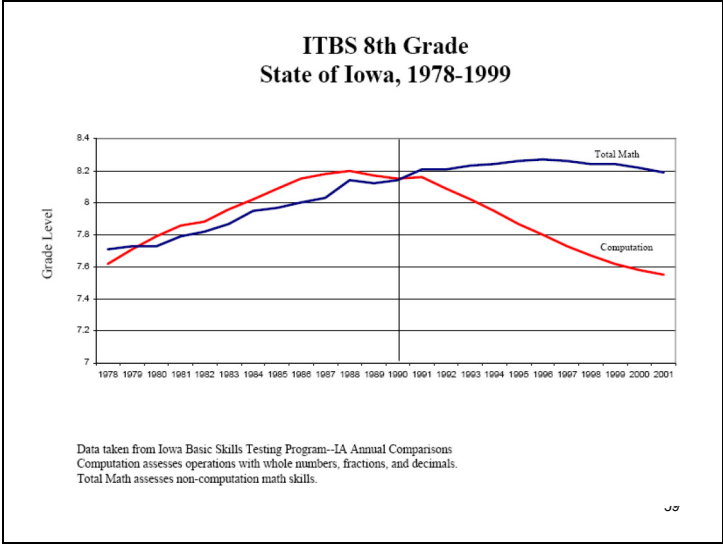
For ~10$^+$ year faculty:

(Vote for ONE:)

Since 2002, I have seen the **computation skills** of first-year students:

A. Improve substantially
B. Improve
C. Not change
D. Decline
E. Decline substantially

38

So we really don't know what's happened since 2002. But I can tell you that every group of chemistry instructors I have surveyed for the past 3 years, including you, has said that since 2002, the math problem in chemistry has gotten

Slide 39

ITBS 8th Grade
State of Iowa, 1978-1999

Data taken from Iowa Basic Skills Testing Program--IA Annual Comparisons
Computation assesses operations with whole numbers, fractions, and decimals.
Total Math assesses non-computation math skills.

Worse since 2001.

1990?

40

What went wrong in 1990? Dr Loveless says this:

Slide 41

"Nearly all state standards after 1990 were modeled on the 1989 NCTM Standards."

-- from Computation Skills, Calculators, and Achievement Gaps: An Analysis of NAEP Items
Tom Loveless, Brookings Institution, April 2004

41

Take a look.

The Math Wars

Short history:

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

Long version:

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

42

What's this about? You can find more information in these references in my posted slides. But briefly:
The National Council of Teachers of Mathematics is a K-12 curriculum group.

1989 NCTM Standards

Recommended for "**INcreased** attention"

In Grade 5-8 math:

* "**Reasoning** inductively and deductively"

* "**Creating algorithms** and procedures"

43

In the early 1990's, 48 of the 50 states adopted standards in math based on what are called the NCTM math standards. Those standards stated that if increased attention in math was given to reasoning,

1989 NCTM Standards

Recommended for "**decreased** attention"

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

44

Attention to these topics could be decreased: Arithmetic, algebra, and fractions.

1989 NCTM Standards

Recommended for "**decreased** attention"

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

45

The idea was well-intended: If you could reason, you would be spared the hard work
Of learning math by memorizing and practice.

"By 2000, all but two states … 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

46

By 2000, every state except California and Massachusetts had adopted these standards, and
nearly all K-12 textbooks changed of necessity to fit state standards.
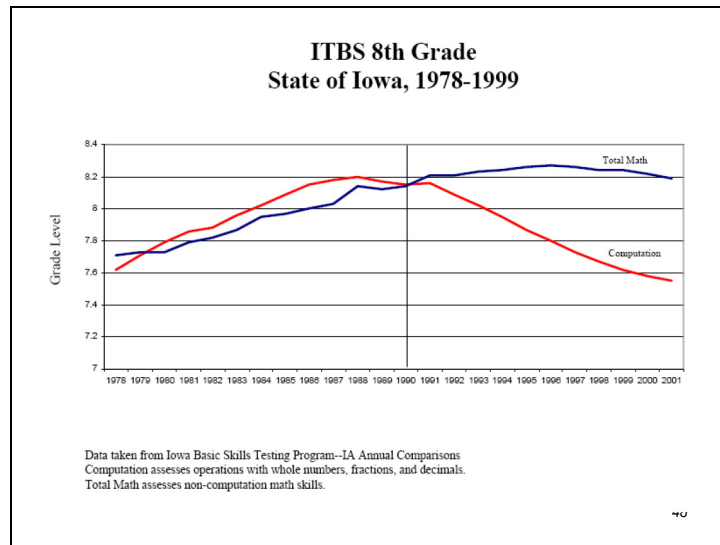
Slide 47

Virginia Math Scores

All students	Grade 9				
	1998	1999	2000	2001	2002
Total Math	54	55	55	55	55
Problem Solving (Reasoning)	58	61	63	64	65
Procedures (Computation)	46	44	42	41	**39**

--Virginia State Assessment Program, Detailed Report
Stanford Achievement Test Series, Ninth Edition (*Stanford 9*)
Statewide Percentile Ranks
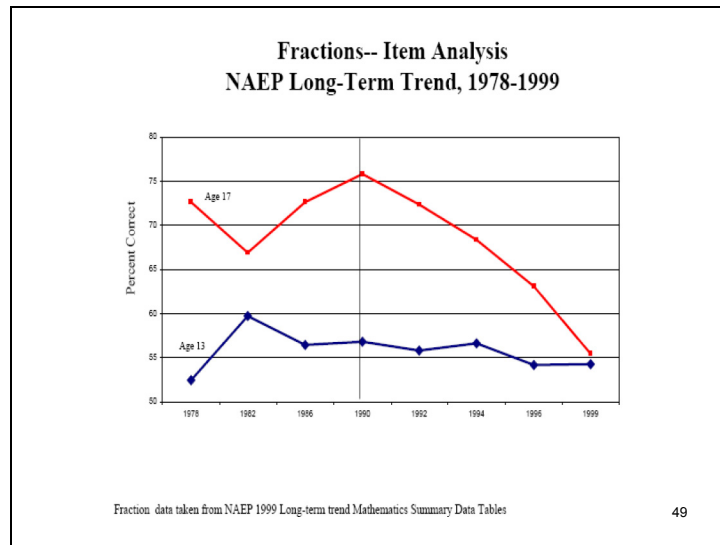2002 Fall Results, Appendix Table 2

47

So, teachers taught and students learned math reasoning. See those scores?

Slide 48

**ITBS 8th Grade
State of Iowa, 1978-1999**

Data taken from Iowa Basic Skills Testing Program--IA Annual Comparisons
Computation assesses operations with whole numbers, fractions, and decimals.
Total Math assesses non-computation math skills.

But the theory about reasoning didn't work, and scores in computation collapsed.

Slide 49

Fractions-- Item Analysis
NAEP Long-Term Trend, 1978-1999

Why Didn't Reasoning Help With Calculations?

50

You might be asking

**2010-2012: New Cognitive
Science Consensus**

2012 Jargon-Free Summary: (6 pages)

Putting Students on the Path to Learning
    by Clark, Sweller, and Kirschner at:

http://www.aft.org/pdfs/americaneducator/spring2012/Clark.pdf

(search "Clark American Educator 2012")

51

Just in the past 3 years, researchers in cognitive science have finally agreed on the answer to the question at the heart of our role as chemistry educators, which is: What do we tell students that **they** need to **do** in order to become **proficient** in **solving** science problems?

There is a new article out that explains this research consensus in six easy-to-read pages.
This is your homework. But let me try to summarize. Here's what those who study how the brain works say that we need to tell our students:

2012: Cognitive Science Says:

• Long Term Memory (LTM) is
  where you store information.
  Human LTM is enormous.

• Working Memory (WM), where
  you solve problems, is limited.

52

Please read this …. And this

2012: Cognitive Science Says:

- **In *working* memory**, you can manipulate up to 4 chunks of info you have not memorized *plus* all you have memorized in Long Term Memory.

- So, **memorization** of fundamentals is crucial for solving problems.

- Each individual must also construct mental models of concepts to tag new info with meaning in your LTM.

53

Here is what it means. To solve problems in a field: you first need to **memorize** the core knowledge of the discipline, while at the same time you construct a conceptual framework to tag this new information with meaning.

I know that for some of us, this finding on the m-word is disappointing.   In the Monty Python Group, we don't like it either. But in 2012 this is now tested, proven science, and in science we pledge to follow this rule:

Slide 54

"If nature does not answer first
what we want, it is better to
take what answer we get."

-- J. Willard Gibbs, Lecture XXX
(courtesy of Bob Hanson)

54

We need to accept the science.

1989 NCTM Standards

Recommended for "**decreased** attention"

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

55

The new cognitive science explains why "decreasing memorizing and practice" did not work as a learning strategy (but to be fair, in 1989, working memory was not well understood.)

2012: Cognitive Science Says:

- **In *working* memory**, you can manipulate up to 4 chunks of info you have not memorized *plus* all you have memorized in Long Term Memory.

- So, **memorization** of fundamentals is crucial for solving problems.

- Each individual must also construct mental models of concepts to tag new info with meaning in your LTM.

56

Way more important, thanks to science, we can now give our students clear and effective advice on how to learn math and science. And this advice is consistent with how all of us learned chemistry.

Conditions:

This research consensus applies:
- Only for Math and Science (WSDs)
- Only Undergraduates and below

57

There are exceptions to the rules. Be sure to read the article.

Impact of
Cognitive Science

58

The new cognitive science has already had impact.

Since 2010: 45 States Adopt
K-12 Common Core Standards

Good on Math!

- "**Fluently** add and subtract within 20."
  (Grade 2)

- "**Fluently** … multiply whole numbers using
  the standard algorithm…." (Grade 5)

- **Fluently** means: fast from memory.

59

Since 2010, 45 states have adopted the new common core math standards.
And they are pretty good. See the word "fluency"? That's the "fast recall" from cognitive science, and it means a restored emphasis on mental arithmetic in K-12.   But…

New Standards Impact:

In 10-20 years

60

You are not going to see the impact of these standards in your entering students for at least 10-20 years.
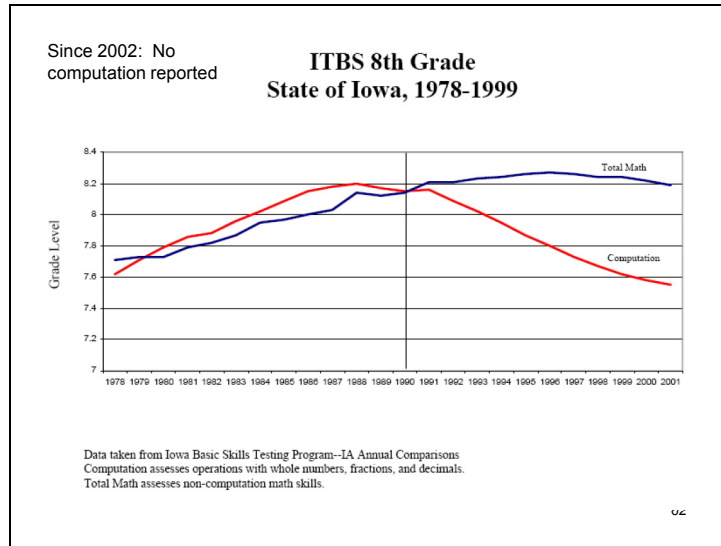
Why?

- Years to create books and tests (2015)
- K-12 book adoption over 6-10 years
- Students + teachers in abrupt transition
- Moving kids from grades 2 to 12 under standards that work = 10 years.
- Ideological, emotional resistance to drill

61

Here's why change in K-12 is going to take a long time. Take a look.

Slide 62

Since 2002: No computation reported

ITBS 8th Grade
State of Iowa, 1978-1999

Data taken from Iowa Basic Skills Testing Program--IA Annual Comparisons
Computation assesses operations with whole numbers, fractions, and decimals.
Total Math assesses non-computation math skills.

Scores fell in Iowa for at least 12 years. Change in K-12 does not happen quickly.

Summary:
In 2012

63

Let's see where we are.

For the next 10-15 years,

will most students
entering college be

able to do
chem math?

64

Please take a look at this question, and now let's vote. How many vote yes, raise your hand? How many no?

Is it their fault?

65

How many vote yes?   No?

Wonderful news.

Now we know
what works.

66

But, thanks to cognitive science, now we have much better understanding of how we can teach needed math in a hurry.

The Monty Python Experiment:

In lecture: Time for activities that construct conceptual understanding.

In homework:
- *Teach* exponentials, fractions, algebra, logarithms.
- Then apply to chem.

67

In our Monty Python lessons, so that instructors have more time in lecture for concepts, in homework we harness cognitive science to teach these four math skills.

Resources on the New
Cognitive Science

68
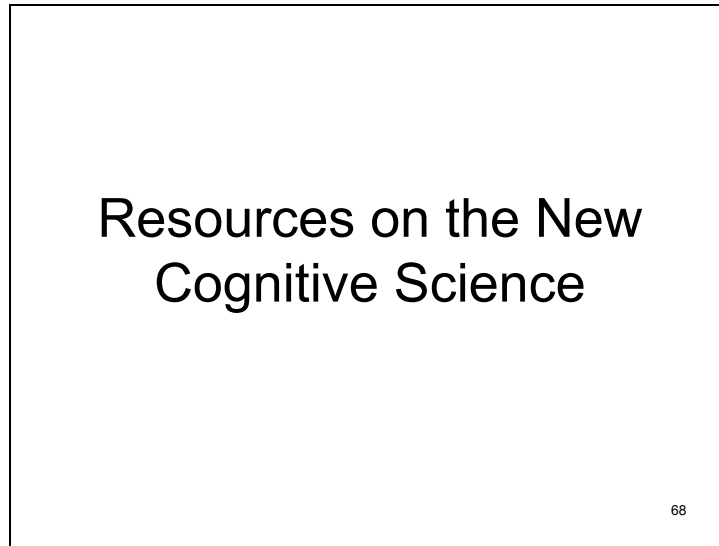
Here are some additional readings on the new cognitive science.

Short Introductory Articles

1. *Spring 2012:* 6-pages on cognition and problem solving:

    Putting Students on the Path to Learning
    by Clark, Sweller, and Kirschner at:

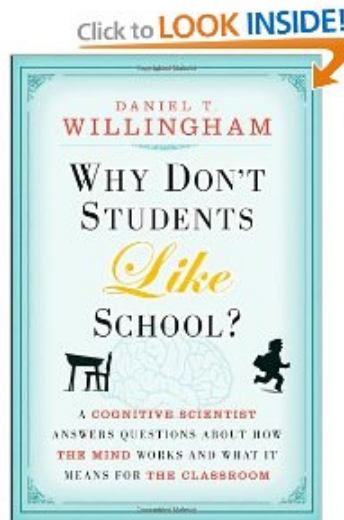   http://www.aft.org/pdfs/americaneducator/spring2012/Clark.pdf

    (search "Clark American Educator 2012")

2. Short, jargon-free articles by cognitive scientist Daniel
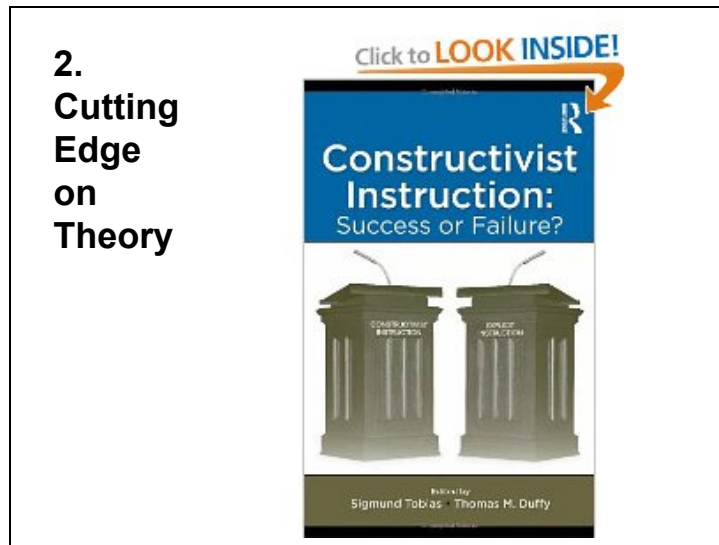   Willingham on topics including critical thinking:

    http://www.danielwillingham.com/articles.html

    69

Books:
1. Easy
Read

Click to LOOK INSIDE!

DANIEL T. WILLINGHAM

WHY DON'T STUDENTS Like SCHOOL?

A COGNITIVE SCIENTIST
ANSWERS QUESTIONS ABOUT HOW
THE MIND WORKS AND WHAT IT
MEANS FOR THE CLASSROOM

Plus two books: Easy

Slide 71

2. Cutting Edge on Theory

Constructivist Instruction: Success or Failure?

Edited by Sigmund Tobias • Thomas M. Duffy

and challenging.

These slides are posted at
www.ChemReview.Net
at the **BCCE** tab.
Feel free to use these data.

Done! Opposing Views?

72

The slides are posted here. Thank you for your patience!