“Common core” standards, student test scores in math computation in some mid-Atlantic states and the implications for chemistry instruction

Presented 5/12/2011 to the
ACS Mid-Atlantic Regional Meeting in College Park, MD

By Rick Nelson, Retired Instructor
EANelson@ChemReview.Net

Q: How can we improve achievement and retention in initial chem courses?

NCTM standards = ?

In my view,

(Vote for ONE:)

For the current generation of students in **first**-year chem, ***math background*** is:

A. Not a problem

B. A minor problem

C. A major problem

Vote for ONE:

To be *prepared* for first-year Chem, it is *most* important for students to have background knowledge in

A. Total Math – math of all types
B. Math Reasoning
C. Math Computation

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

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

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

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

-- Zumdahl, 5th edition

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

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

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

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

Thus

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

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

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

-- Zumdahl, 5th Ed. p. 218

Vote for ONE:

In first-year Chem, it is *most* important for students to have background knowledge in

A. Total Math – all types
B. Math Reasoning
C. Math Computation

In chem, which one is MOST important?

For ~10^{+} year faculty:

(Vote for ONE:)

During the past **10 years**, I have seen the ***computation skills*** of first-year students:

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

- What’s the problem?
- Why the problem?
- How can we fix the problem?

Maryland: Math Remediation

Among MD HS students who took the SAT or ACT in 2008 and who enrolled in MD public colleges or universities:

- **Core** students = 3 years of HS Math and 2 years of HS science; **Non-core** students = not.

A *remedial math* course in college was needed by

- **32% of core students** and 49% of non-core students.

Including, at University of Maryland system campuses

- 14% of core students and 27% of non-core students.

And at MD community colleges

- 56% of core students and 69% of non-core students.

- **Virginia**
- **Statewide Remediation**
- Graduated at a Virginia HS, enrolled in remedial MATH in **VA** college:
  - 2002: 17%
  - 2010: 18%

-source: SCHEV

Virginia Math Results:

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

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

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.”

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**
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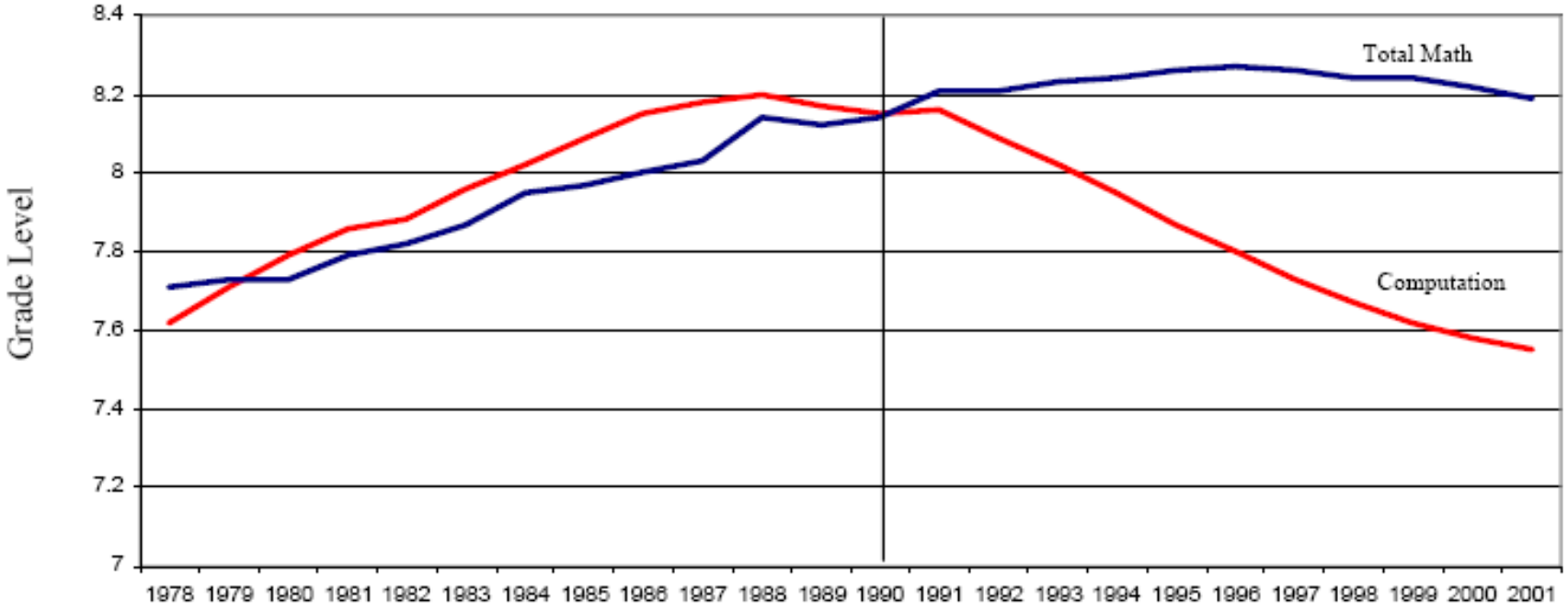
Evidence: (from sample of 80,000 students)

- They were learning SOME math! But not math needed for science
- Reasoning did not help with computation: No transfer.
- "Total Math" scores tell nothing about reasoning and computation.
- 39th percentile = Not many ready for chemistry.
- Why these results?
- Do Virginia results apply to other states?

Next three slides from:

Tom Loveless
Brown Center on Education Policy
of the Brookings Institution
Presentation on Math Reform
at AEI March 4, 2002

ITBS 8th Grade
State of Iowa, 1978-1999



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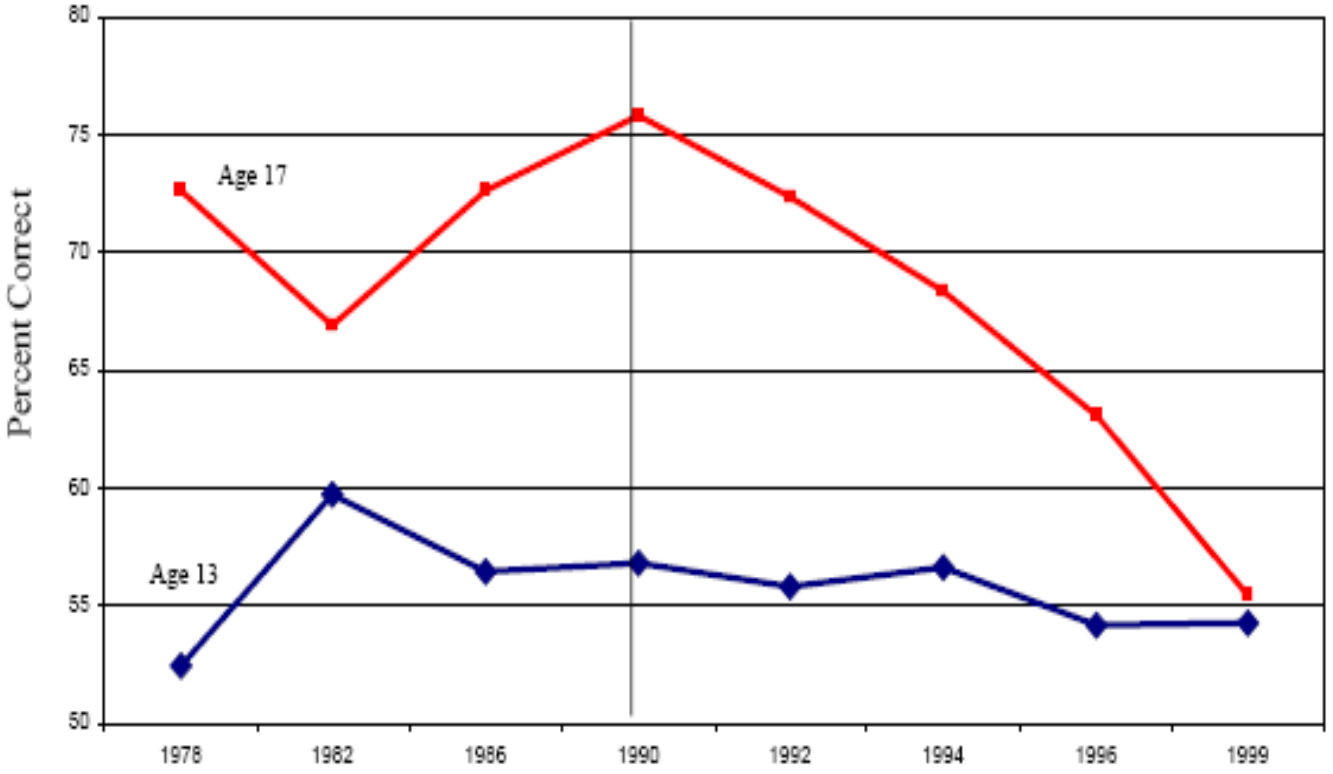
Fractions-- Item Analysis
NAEP Long-Term Trend, 1978-1999



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Thus

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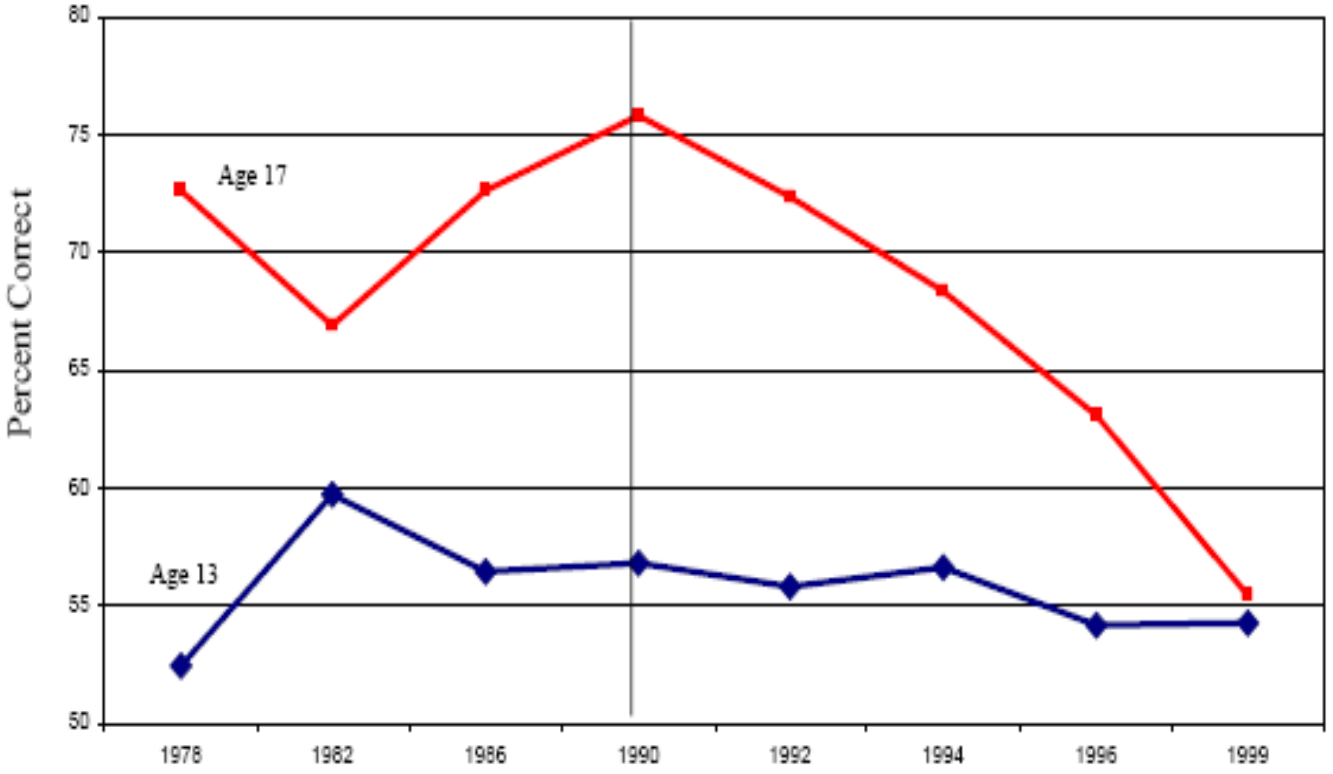

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In Preparation for Chem
is "**Math**" the problem?

The evidence is: No.

ITBS 8th Grade
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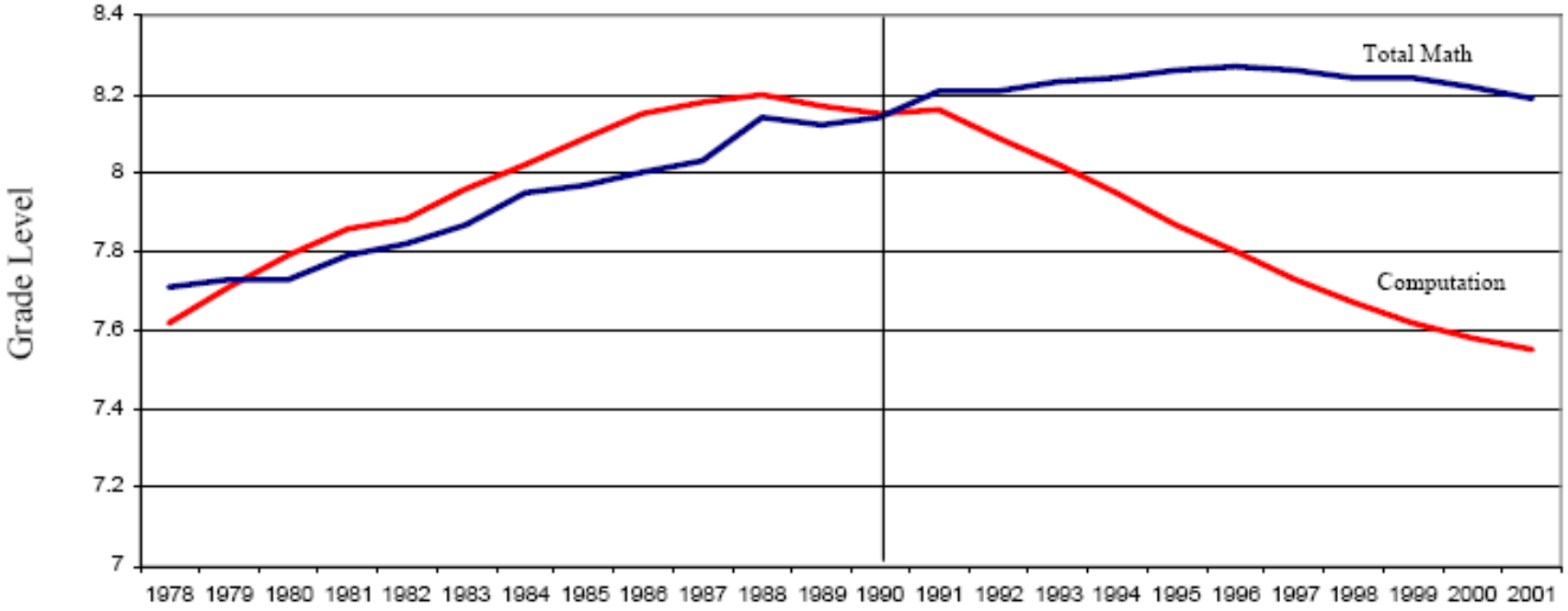

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The problem is computation.

Implications for Chem Depts?

- It’s not 1990

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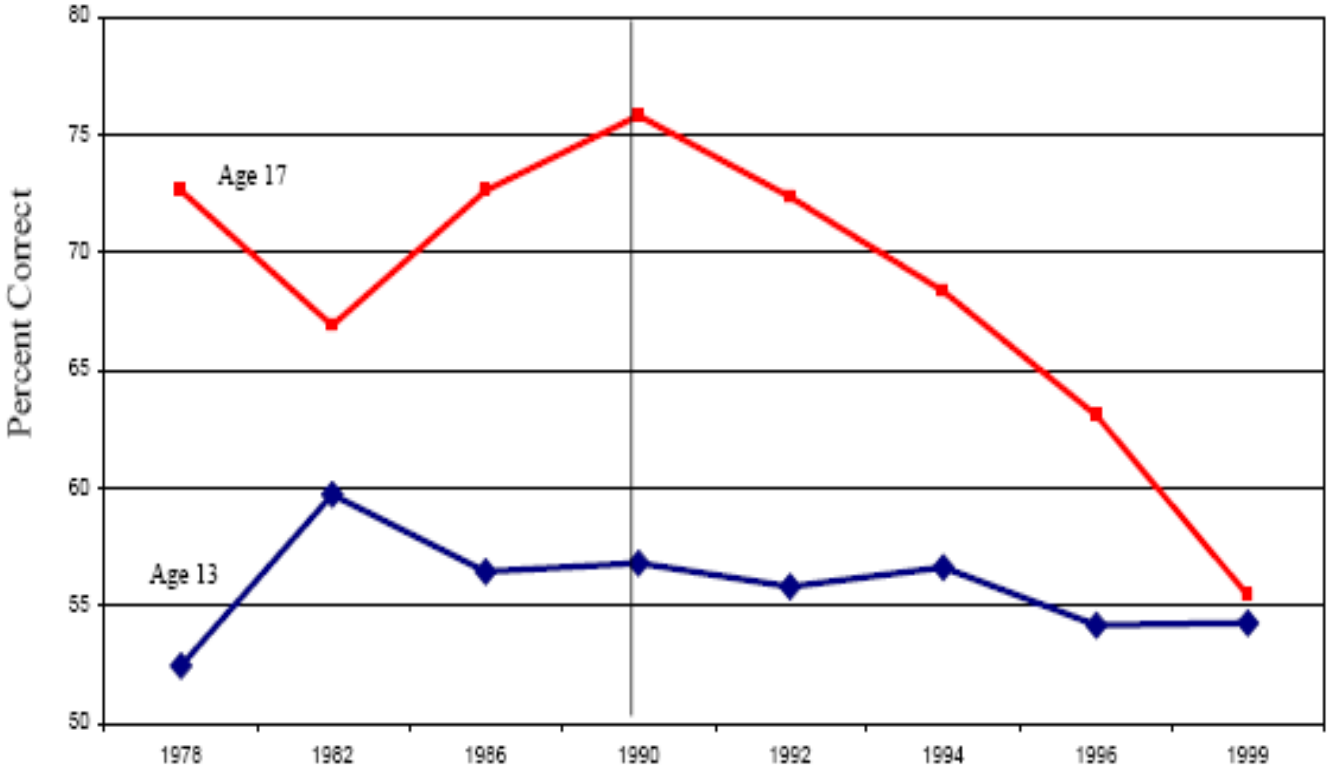

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Implications for Nation?

In ~1990, **Why** the Change?

"The **1989** NCTM standards played the role of national standards….

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, The Brookings Institution, April 2004

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

NCTM's *An Agenda for Action (1980):*

- "All students should have access to calculators and increasingly to computers throughout their school mathematics program."

New Jersey
-- Current Math Standards

STANDARD 5 — TOOLS AND TECHNOLOGY

K-12 Overview

All students will regularly and routinely use calculators, computers, manipulatives, and other mathematical tools to enhance mathematical thinking, understanding, and power.

NJ: Use Calculators in 1st Grade

- **Q and A**
  Core Standards in Mathematics
  NJ State Board of Education – 2002 to current

- **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

To Balance:

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

Use a calculator?

1989 *NCTM Standards*

Recommended for "**INcreased** attention" were

In Grades 5-8:

- "**Reasoning** inductively and deductively"
- "**Creating algorithms** and procedures"

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In Grades 5-8:

- "**Reasoning** inductively and deductively"
- "**Creating algorithms** and procedures"

1989 *NCTM Standards*

Recommended for "**decreased** attention" were

- "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",

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

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Was this taken seriously?

"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

- Take a look at K-12 math books.

- See how much content is preparation for scientific calculations.

Results Make Sense?

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Why no computation data since 2002?

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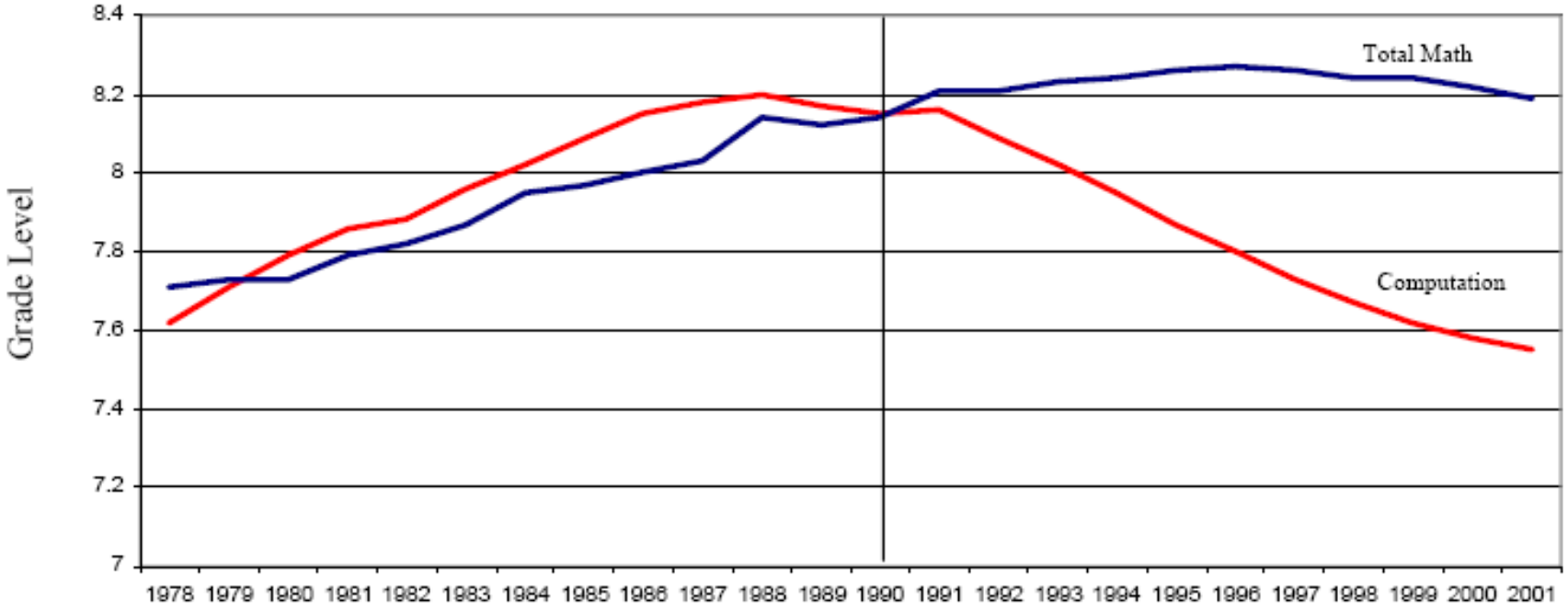

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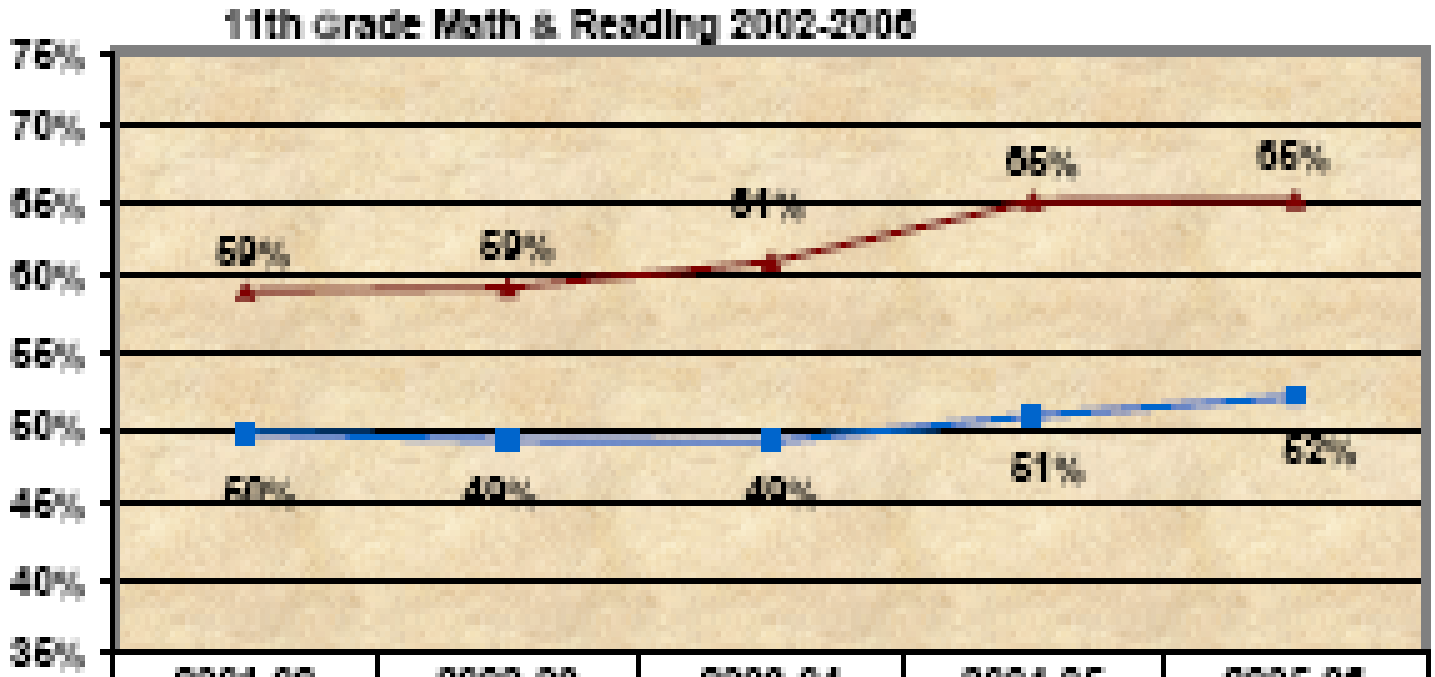
2003: Computation Data STOP

- NCLB Mandates Tests versus State Standards in Grades 3-8
- Most states stop *nationally normed* tests, and
- Since 2003 : NO state reports math *computation*

Pennsylvania:



	2001-02	2002-03	2003-04	2004-05	2005-06
11th grade math	50%	49%	49%	51%	52%
11th grade reading	59%	59%	61%	65%	65%

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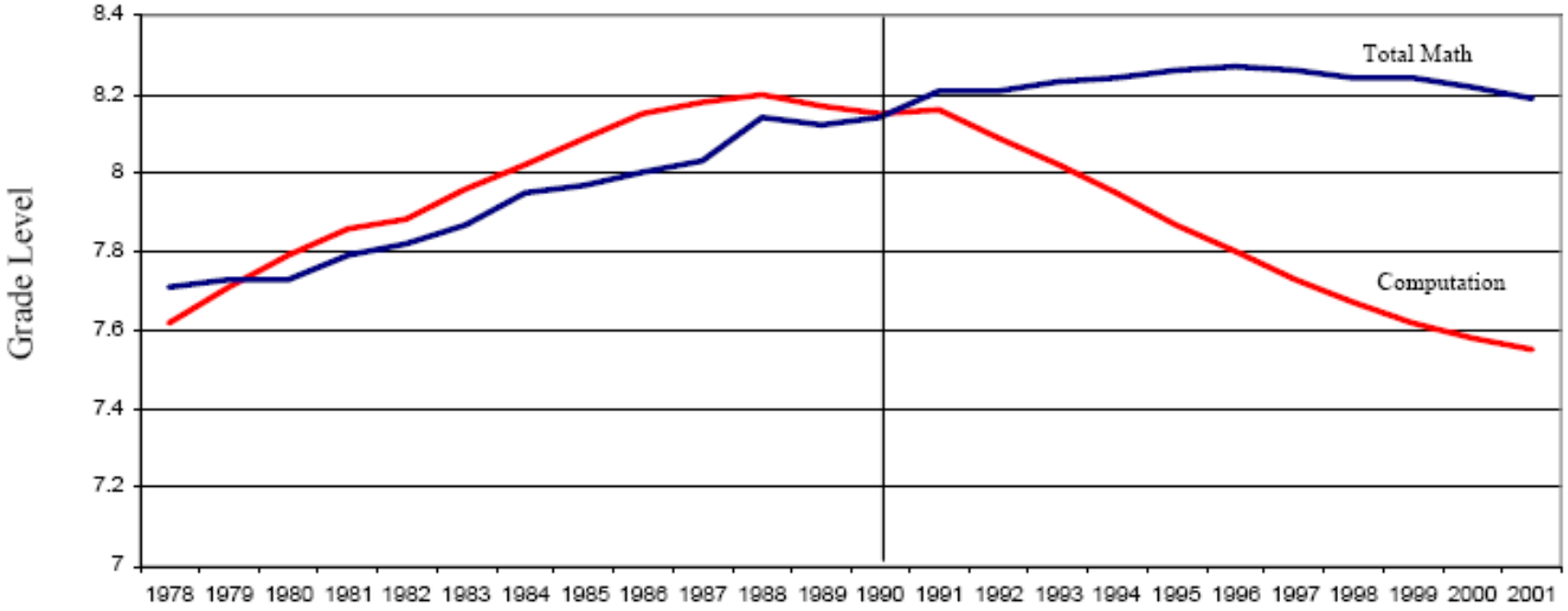

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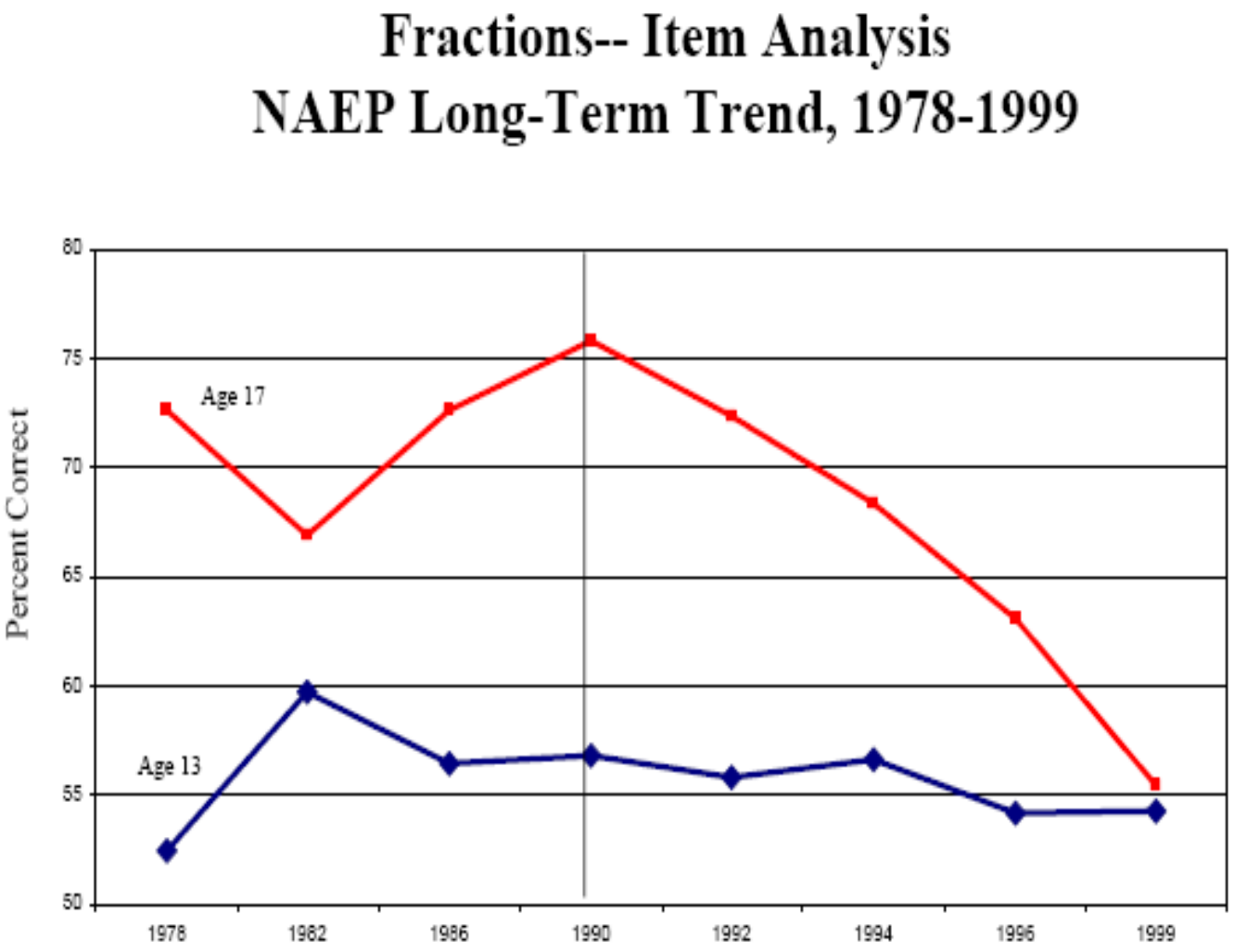
2003 to 2010

- STEM *talk*, but readiness not measured.
- $$ Millions/yr spent on state K-12 tests, but
- Computation scores not reported,
- Readiness for chem, physics, engineering? Dropped to 2002. Now? No data.

Was this the students' fault?



The Bohr Model

How do we
FIX
the **problem**?

~2006: Cognitive Science Says

- You solve problems in Working Memory
- Working memory is VERY limited when manipulating information NOT in Long-Term Memory
- Fast recall of fundamentals (fluency) from Long-Term memory overcomes limits in Working Memory.

Fix #1:

Standards That Include Computation:

Good News.

New K-12 Math Standards

2010: National Governor's Assn. proposes (& feds push with $$$)

- K-12 "Common Core Standards"
- Non-federal, state voluntary "National Standards"

2010-11:

44 states adopt Common Core stds.

For a review of the Common Core Math Standards:

- http://edexcellence.net/doc/20100323_CommonCoreReview_Math.pdf

Good on Computation:

- “By end of Grade 2, fluently add and subtract within 20. Know from memory sums of one-digit numbers.”
- “Fluently … multiply whole numbers using the standard algorithm….” (Grade 5)
- Fluent means: fast from memory.

When Will New Standards Help?

- 3 years to get books/tests on new stds.
- 6-10 years of gradual K-12 text purchase
- Students caught in abrupt transition
- 10+ years to put students through under new standards.

Not for 10-20 years

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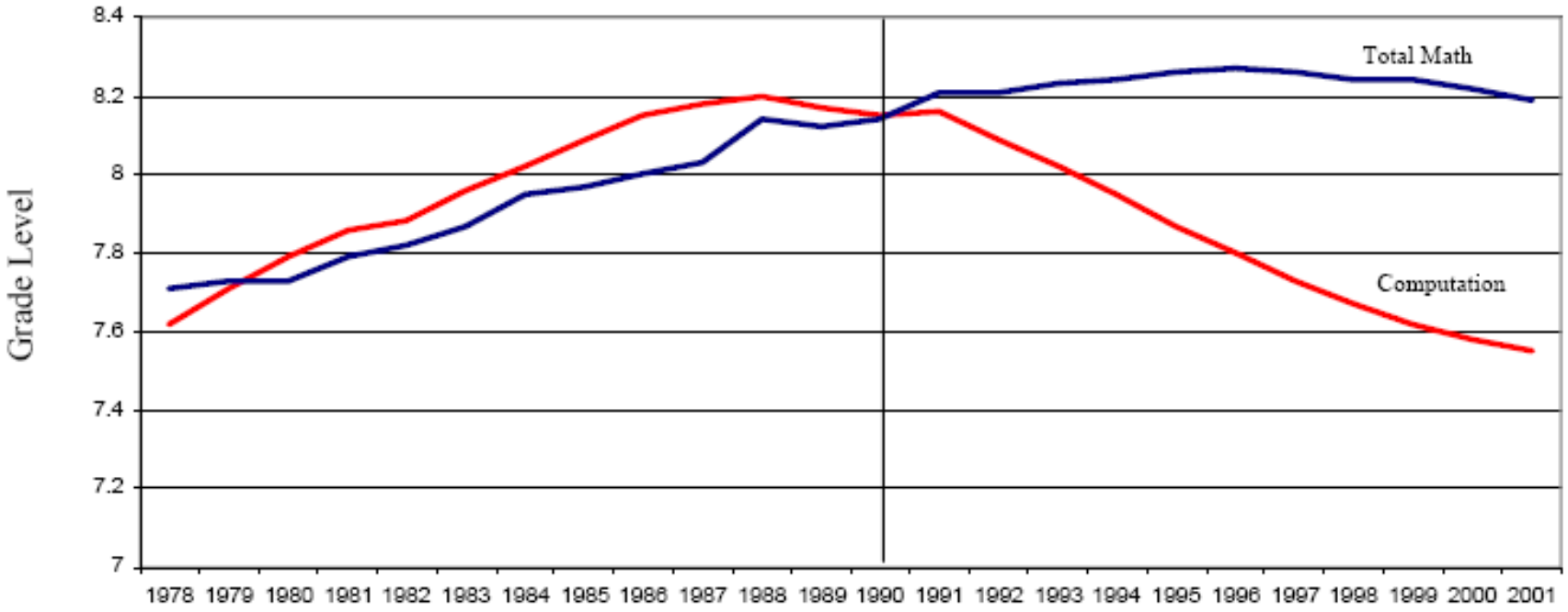

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Fix #2

- Ask your state to report computation

  (versus time, standards, international norms).

  Tested = Taught

  If Reported = Sooner Fixed

Fix #3:

In Chem, Address the Computation Deficits While Waiting

2011 to 2030

If we want

- more majors
- More Gen Chem success

Offer students practice in math pre-requisite for chemistry

Is this Remediation?

Computation Teaching Options:

1. Integrate *Computation* instruction and practice into Gen Chem homework.

And/Or

2. One Credit
   concurrent with Gen Chem I
   "Prep for *Calculations*"

And/OR

3. 3 Credit "Prep Chem" -- but
   focused on *computation*.

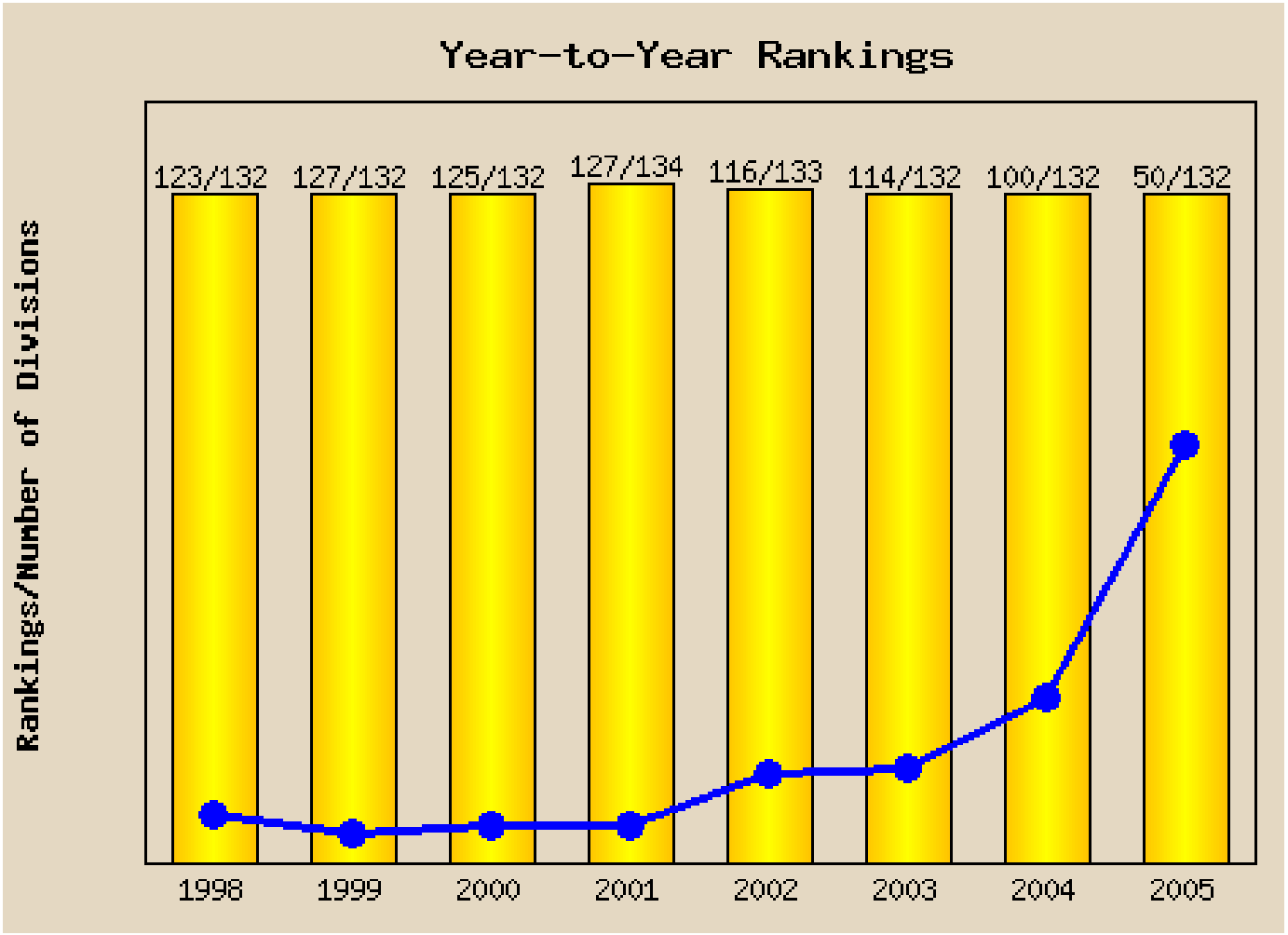
- 1,000 pages of free chem *computation* homework options, with instructor reviews, at www.ChemReview.Net

- Math of chem -- with & **w/o** a calculator

Can Improved Curriculum Help?

Good News

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.



Stanford 9 STAR California Standards

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

California Science Enrollment

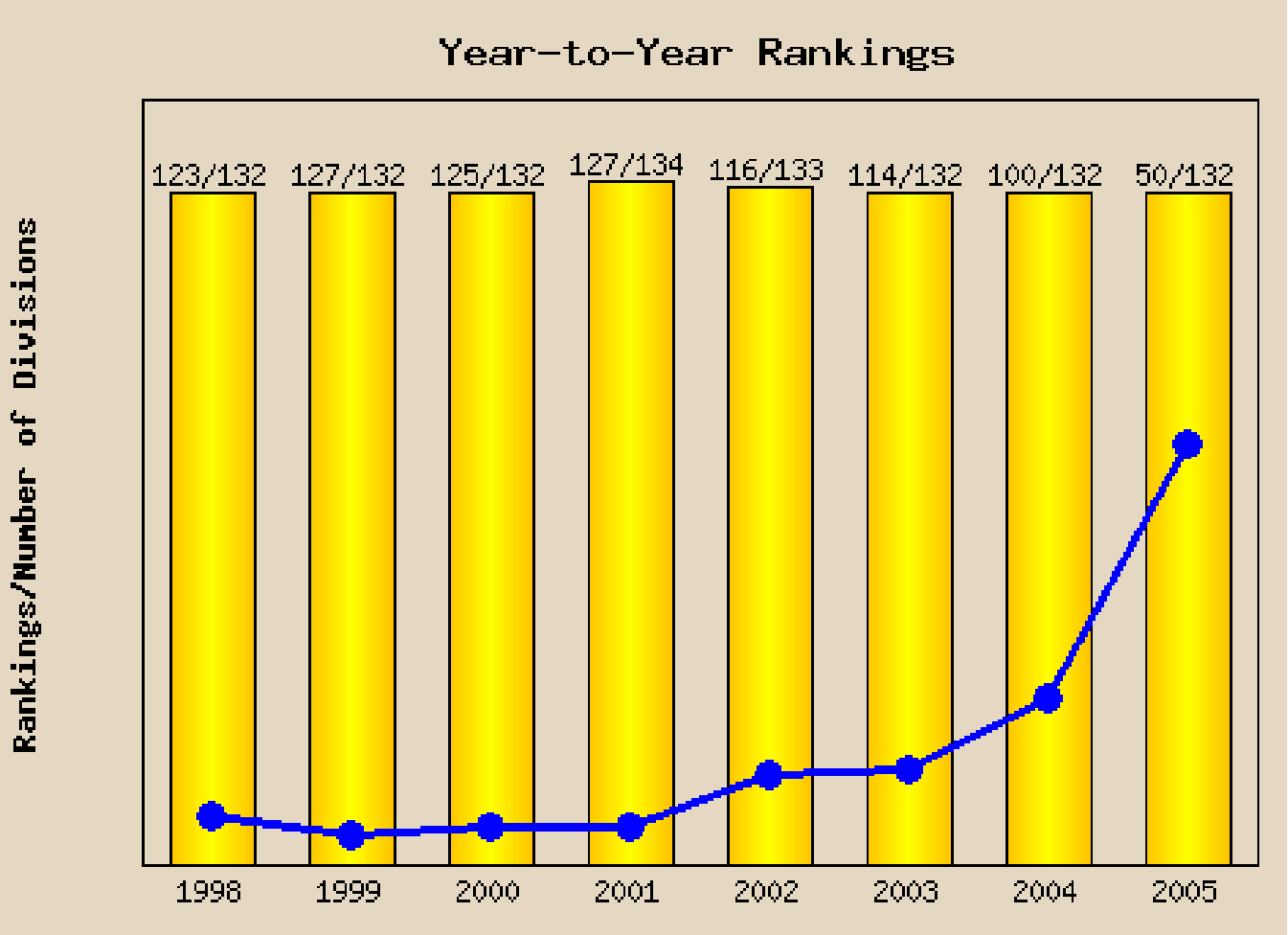
Science—End-of-Course (Grades Nine Through Eleven)

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

Using Cognitive Science,

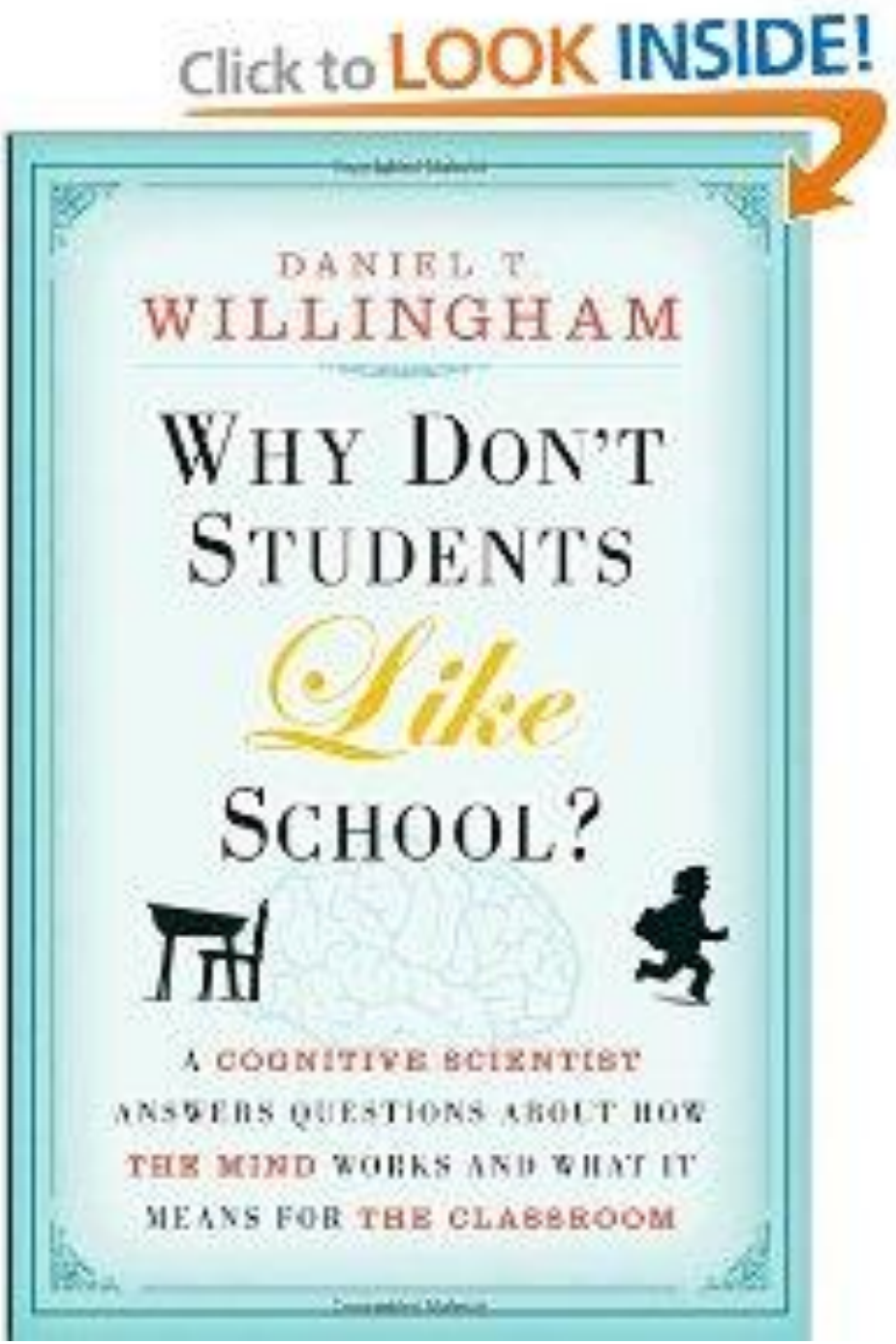
Achievement Does This:



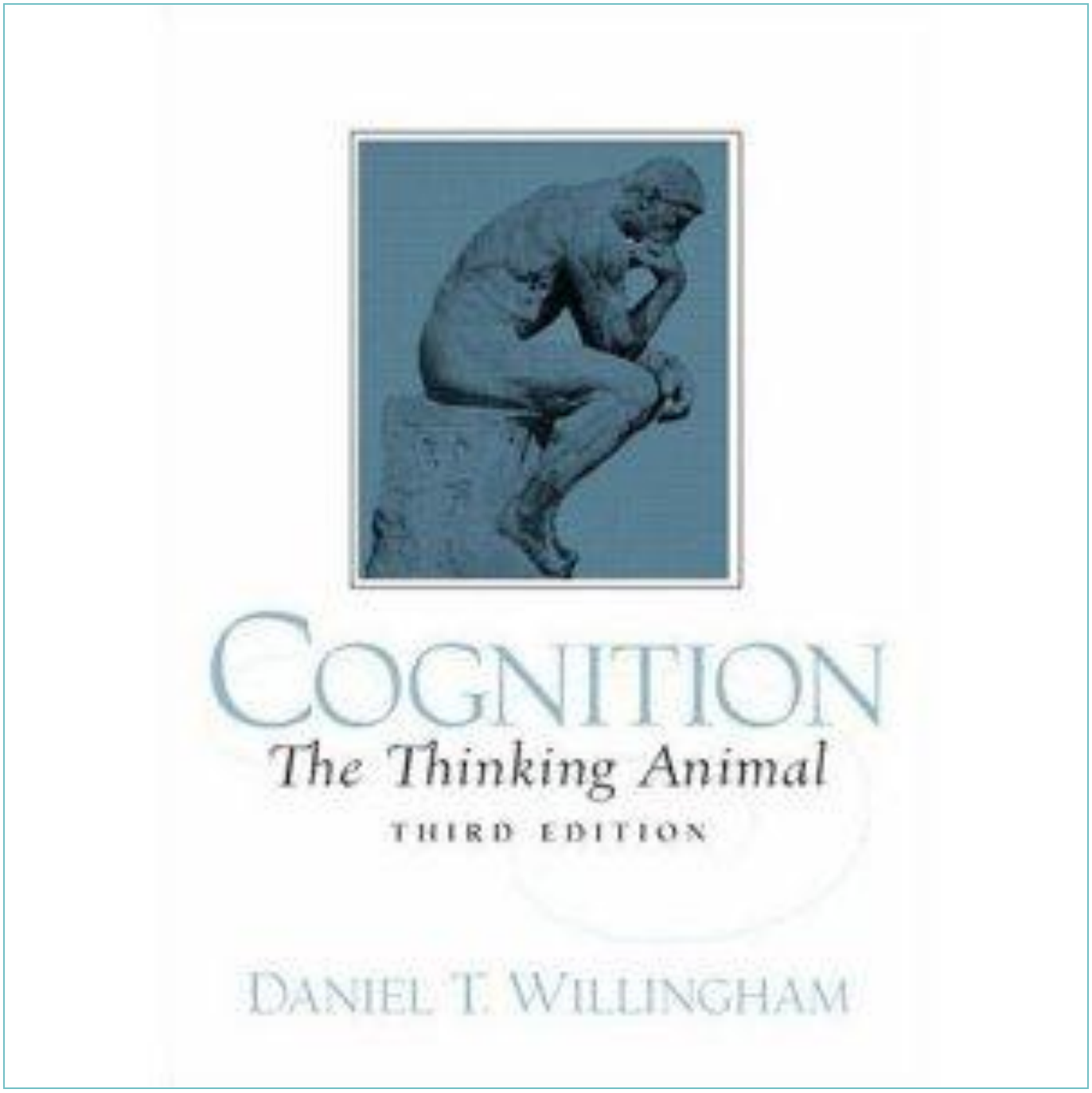
Chemistry Education

3 Books on the New Cognitive Science:

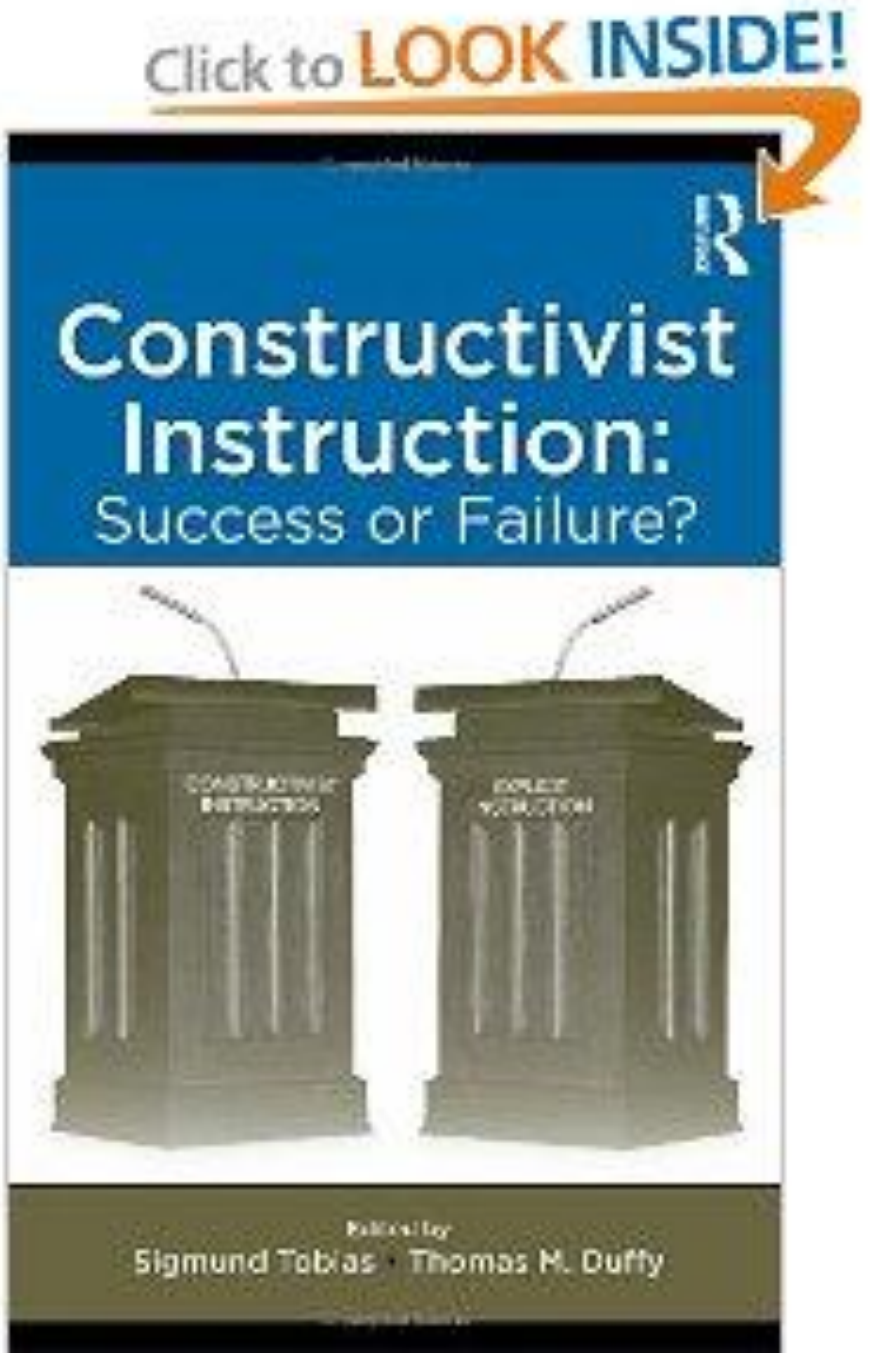
1. Easy Read



2.
Cog Psych Textbook



3. Cutting Edge on Theory



Gen Chem

Gateway to Science and Engineering

that is the

Foundation for America.

We Need Students *Ready*

For Gen Chem

Summary

- Student Preparation for Chemistry ↓ ↓ ↓
- States De-emphasized K-12 Computation
- Impact on National Economy
- Fixed Standards: Impact 10-20 years out
- Teaching Science-Math falls on us
- New Cognitive Science can help

These slides are posted at

www.ChemReview.Net

at the MARM tabs on the left.

Please feel free to use this data.

Done! Questions?

Backup and Question Response Slides follow

In your head:

$$\begin{array}{r} 76 \\ \times\ 67 \\ \hline \end{array}$$

Solving Problems

The Cognitive Science Model: We use

- Long-term memory (enormous)
- Short-term memory (short and limited)
- Working memory
  - Where we *think* and *solve* problems
  - VERY limited in handling *new* data

Limited Working Memory

"We can hold no more than about seven *novel* elements (not in LT memory) of information in working memory and can process no more than about 4 elements depending on the nature of the processing required."

-- J. Sweller in *Constructivist Instruction: Success or Failure* (2009), p. 136, citing N. Cowan, The magical number 4 in short-term memory, *Behavior and Brain Sciences, 24,* 87-114

When Solving a Problem

Working memory can manipulate

- **4 chunks** of **new** information

Plus

- All that can be recalled “with automaticity” from LT Memory.

Major factor? Content in LTM

Overcoming Limits on Working Memory

- Fundamentals of the discipline memorized to automaticity

And

- Memorized algorithms that “chunk” information and processes

Memorization?

- “Data from the last 30 years lead to a conclusion that is not scientifically challengeable: thinking well requires knowing facts…. The very processes that teachers care about most-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).

  *There is one important exception-how experts think. 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

Cognitive Science recommends

Homework

- Memorization of core facts of discipline
- Practice at applying algorithms

During Class

- A focus on concepts
- Guided inquiry to build cognitive frameworks and interest
- Do the Shakhashiri