SYMPOSIUM ON LEARNING ANALYTICS AT MICHIGAN

What Students Learn from What and How?

And Is this OK with you?

http;//RELATE.MIT.edu

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Teach→Learn: Assess Learning

What Are Students Learning?

COMPARE TWO ASSESSMENTS: compare A- and C

What Activities cause learning?

Book, tutorial, class, homework, laboratories, part ii of problem 7

- Much Harder to Determine

What Habits are bad or good?

Must Stop Bad, and Encourage Good

Are We Teaching the Right Stuff?

According to Whom?

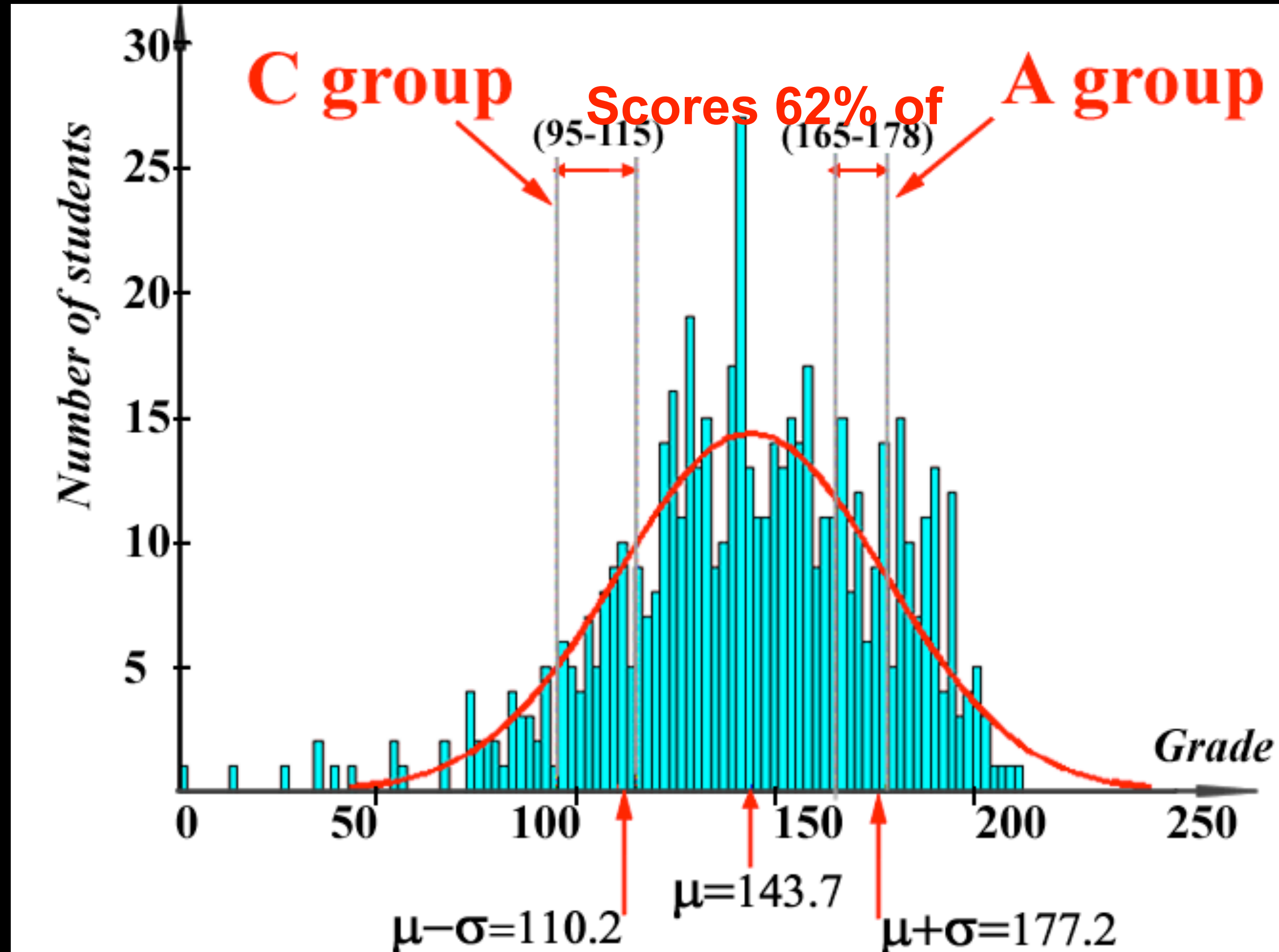
Themes: Problem Solving and Data

I want my students to learn to solve problems that involve combining known principles in new ways, i.e. multi-concept problems whose givens and unknowns are not connected in any single formula in the book.

Data >>>Opinion

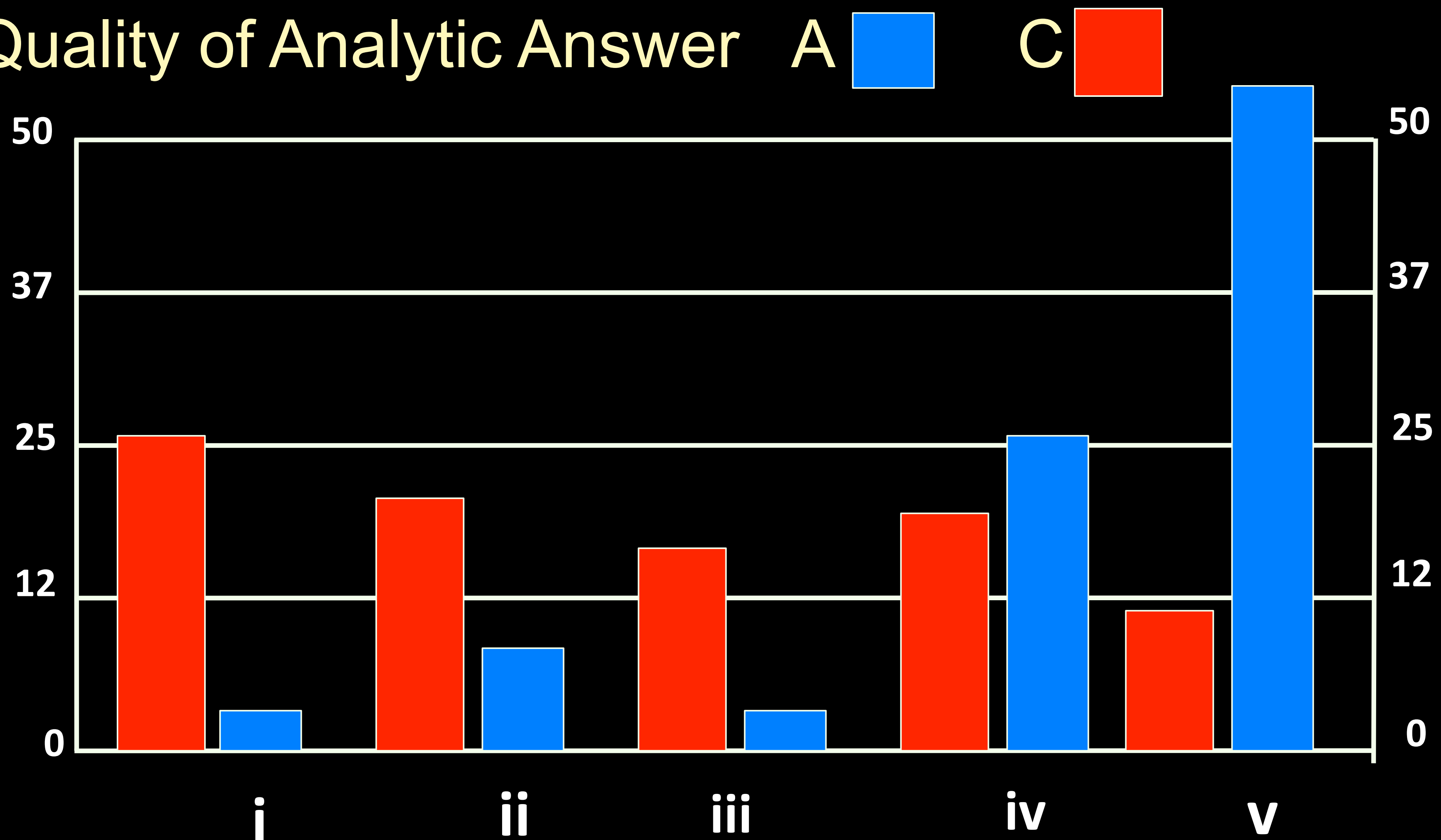
Allows scientific improvement

What does observed 2 sigma learning Mean?



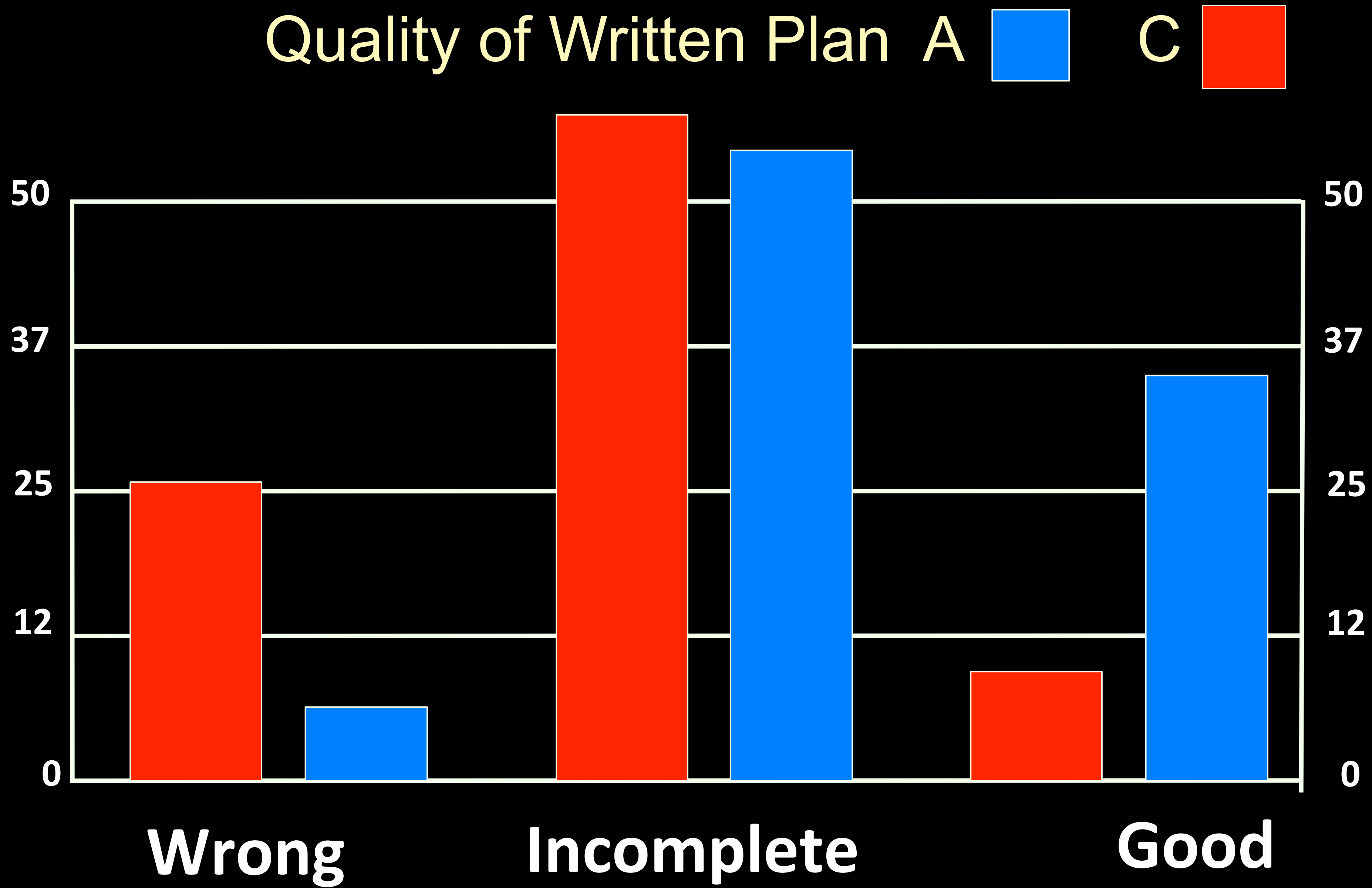
- A- group (1 Sigma +): a reasonable expectation of what students should/could learn
- C group (1 Sigma -): pass with no reservations
- **What A- students learned that C students didn't**

Quality of Analytic Answer



A's completely correct >50% vs 10%

C's significantly wrong ~50% vs ~12%



Verbal Plans of Both Incomplete > 50% of time!

Summary of Performance

- **C score 79% of average, 62% that of A's, but:**
- **A's: Very Good analytic or verbal 4x C's**
- **C's: wrong 4x A's**

CONCLUSION:

- **Partial Credit Grading Rewards**

Partial Understanding

What activity(s) are they learning from?

Can't Improve Learning w.o. Knowing This!

Pre and Post Testing Gives Gain

-then study
What Students with High Gain Did

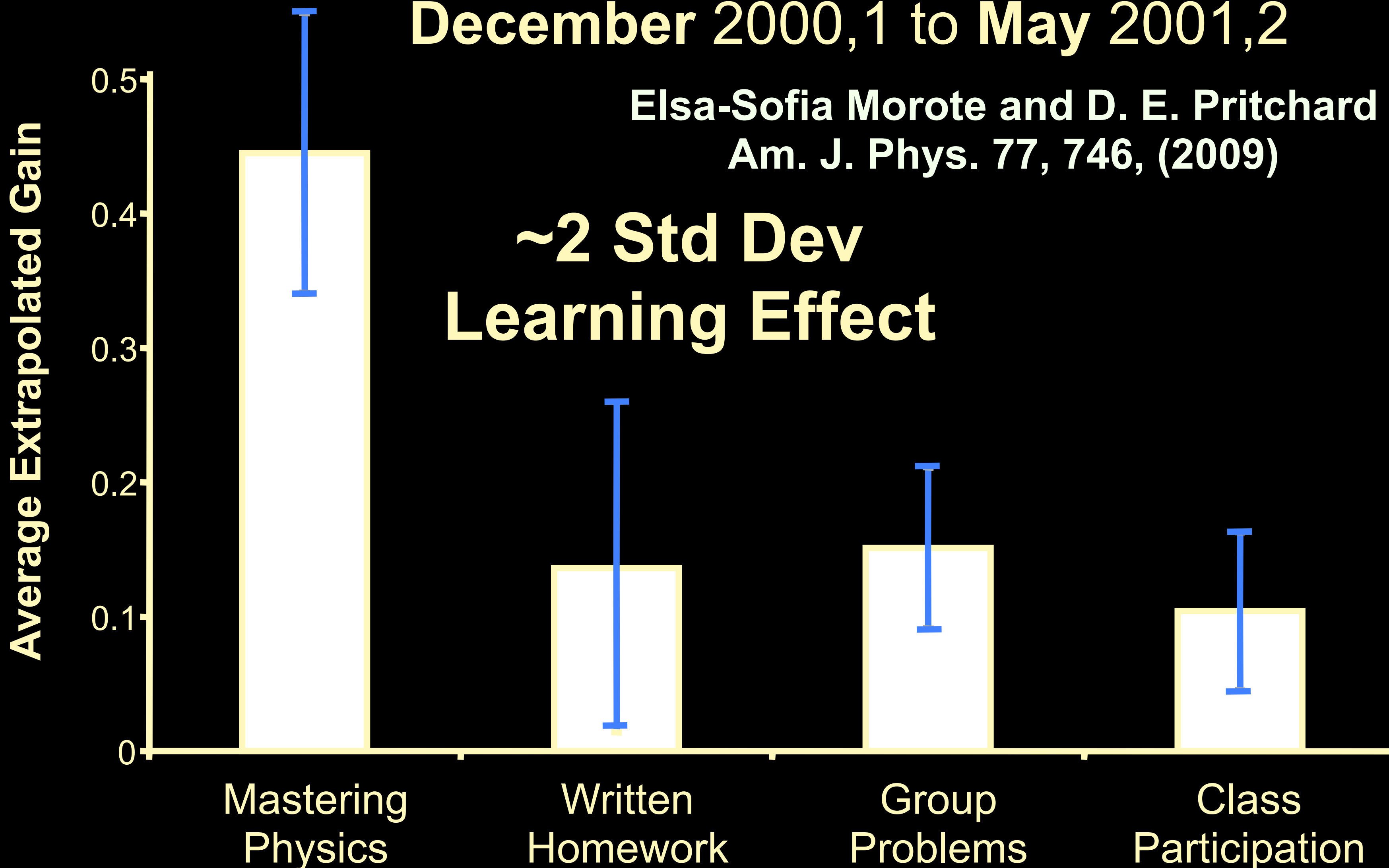
Course Activities: **recitations, written HW, online HW, group problems**
Correlate - amount of each element with improvement

- Just a correlation: causation by inference

Gain on Final Exam

December 2000,1 to **May** 2001,2

Elsa-Sofia Morote and D. E. Pritchard
Am. J. Phys. 77, 746, (2009)



p-values 0.00002 0.26 0.013* 0.076

Plan of This Talk

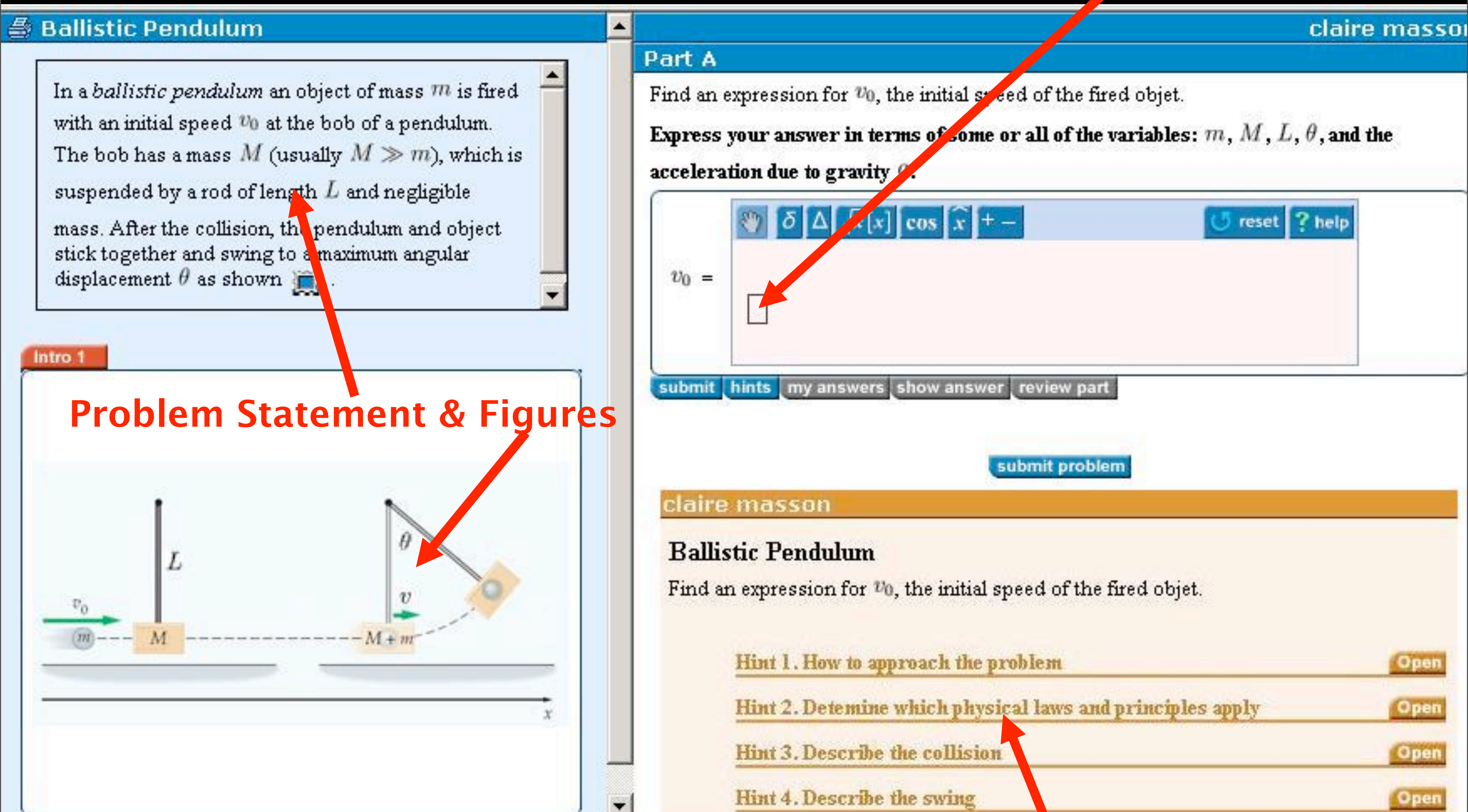
- 1. What A- students learned that C didn't (4x)
- 2. What they learned from (online homework)

- Now: Online Socratic Tutor
  - Great Data for Data Mining

- Next: HABITS, good and bad

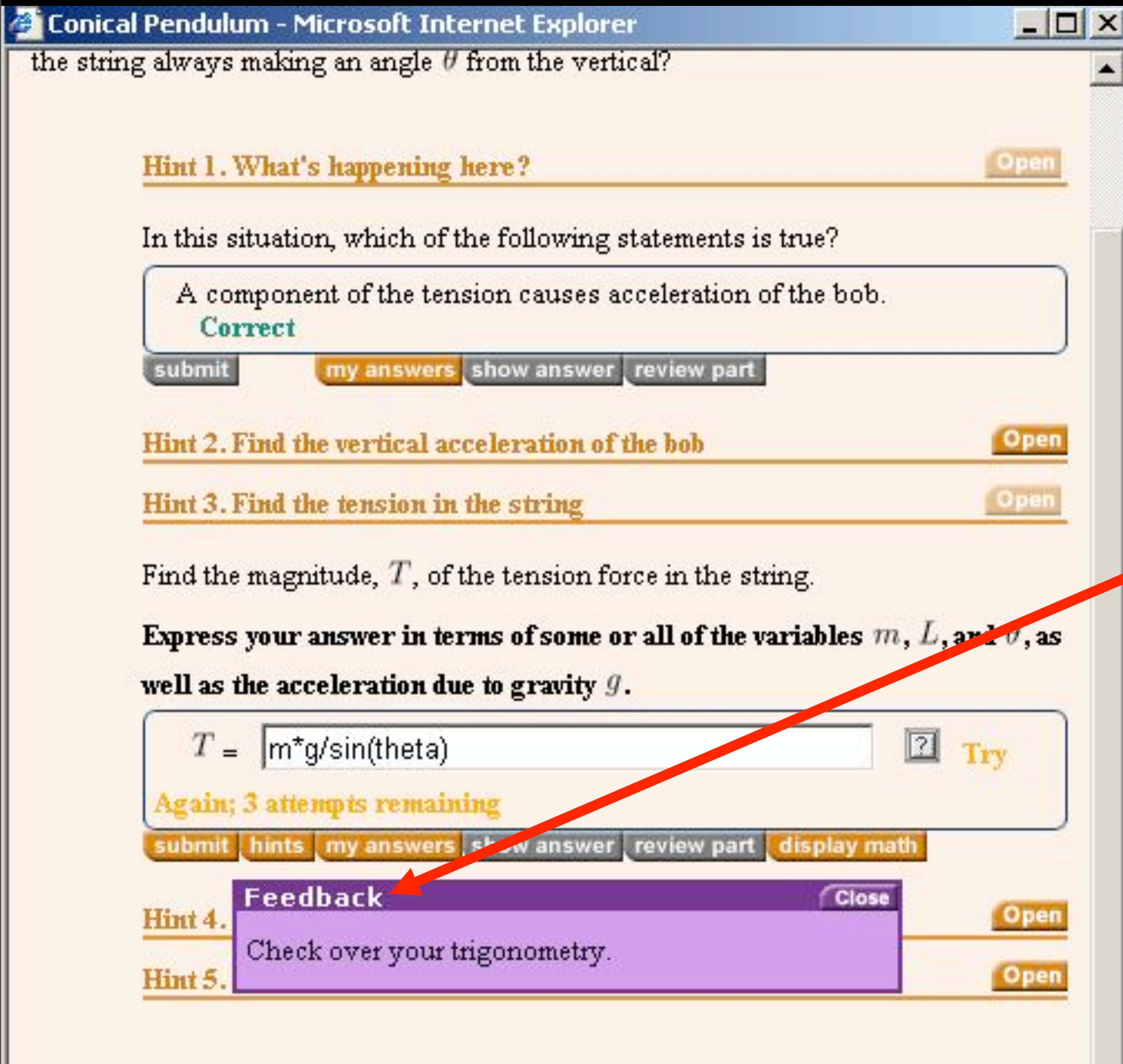
Socratic Pedagogy of MasteringPhysics.com

Demand Appropriate Response



Requestable List of Hints (plan of attack)

Wrong Answer Feedback



Feedback Addresses Particular Error(s) in Student's Response with advice or challenge

Declarative Hint

claire masson

Ballistic Pendulum

Find an expression for v_0, the initial speed of the fired objet.

Hint 1. How to approach the problem Open

There are two distinct physical processes at work in the ballistic pendulum. You must treat the collision and the following swing as two separate events. Identify which physical law or principle applies to each event, write an expression to describe the collision, write an expression to describe the swing, and then relate the two expressions to find v_0.

Hint 2. Detemine which physical laws and principles apply Open

Hint 3. Describe the collision Open

Hint 4. Describe the swing Open

Hint 5 Open

This hint will be visible after you complete previous item(s).

Hints open on request in any order.

This is a Declarative Hint.

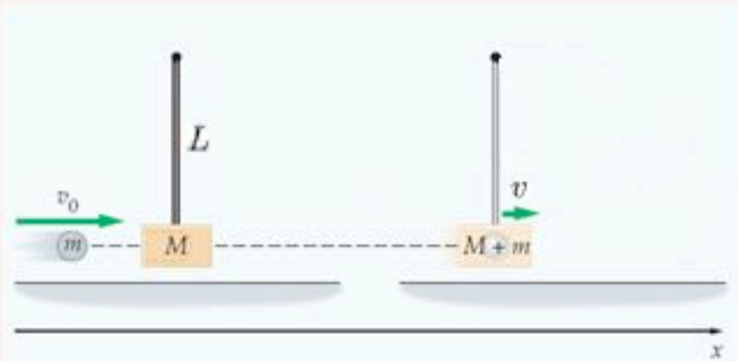
It Informs, Suggests, Reminds, etc.

Socratic Hint (Subtask)

Hint 2. Detemine which physical laws and principles apply Open

Hint 3. Describe the collision Open

Write an expression that describes the collision between the object and the pendulum bob. Write this expression in the form $v_0 = \cdots$.



Express your answer in terms of some or all of the variables: m, M, v_0, L, θ, **and the acceleration due to gravity** g.

v_0 =

submit | hints | my answers | show answer | review part

Hint 4. Describe the swing Open

Hint 5 Open

This hint is a SubTask

It Requests a Response that helps answer the main question.

Responding is optional, although informative.

Eductional Data Mining: Tutors give DATA!

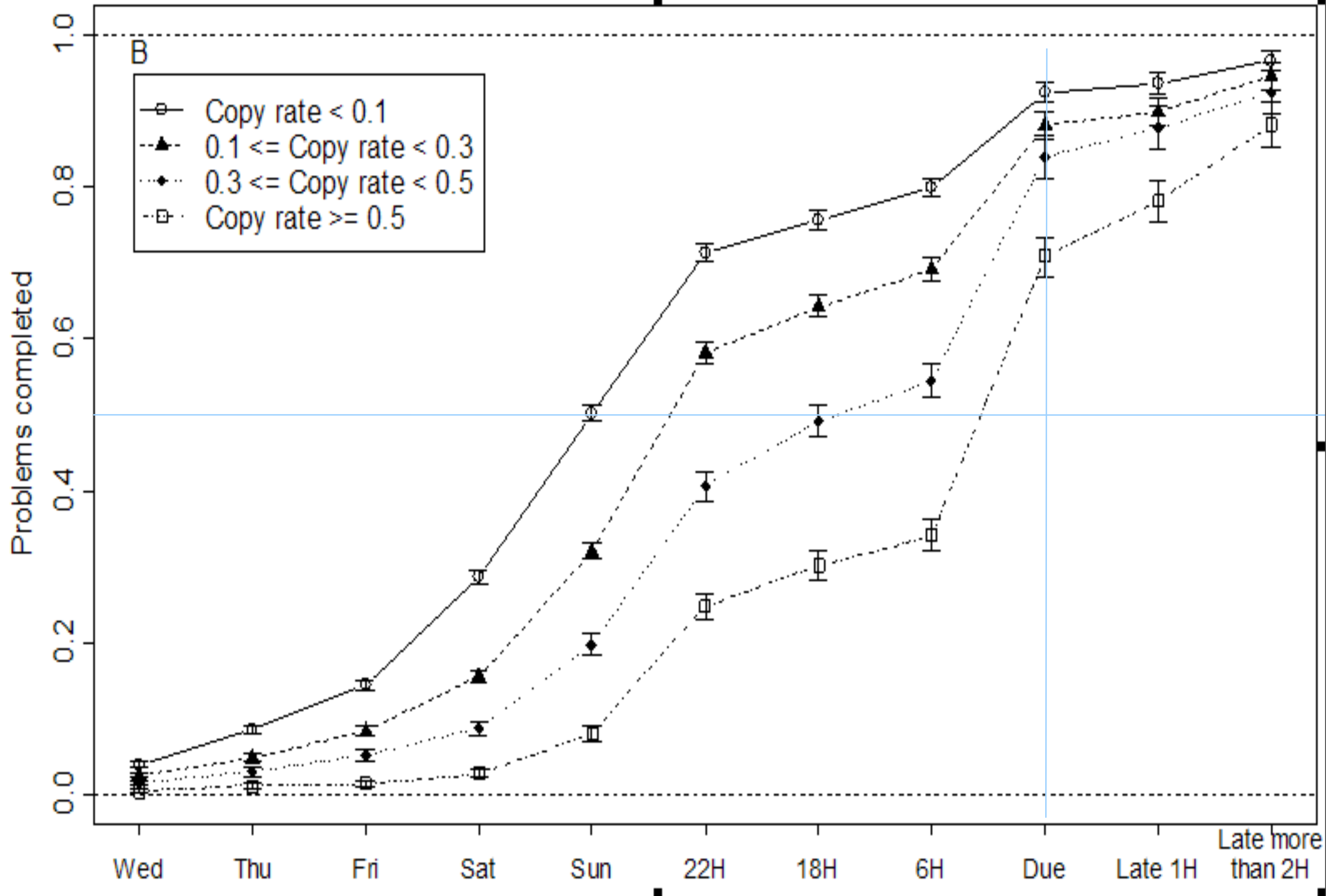
Fine Grain Assessment – Holy Grail

- Assessment of Detailed Mental State
- Guide for the Teacher
- **Ultimately will guide individual tutoring**

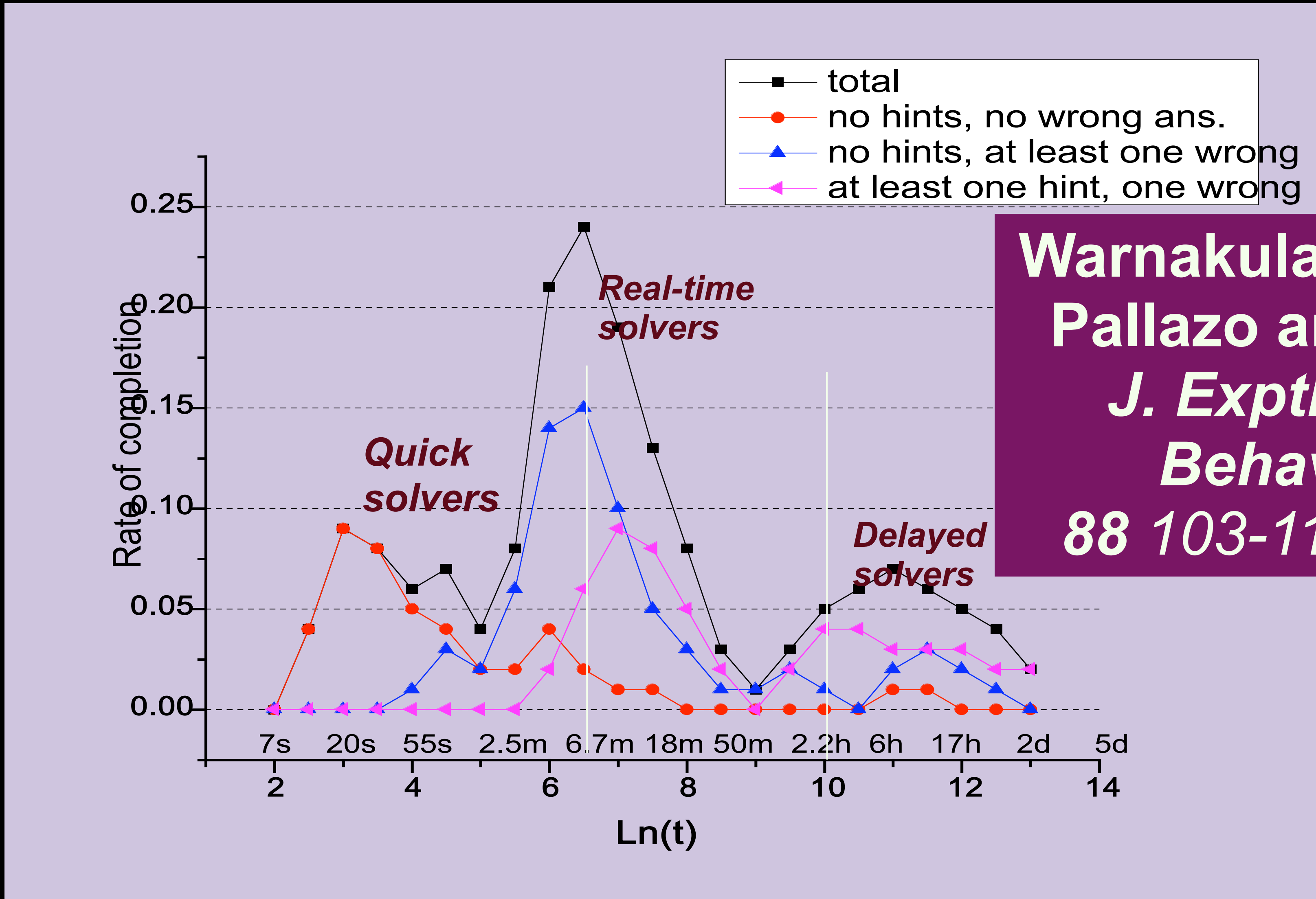
Habits of Mind and Behavior

- What Habits help/hinder learning??
- Homework copying reduces learning
- Better to open hints prior to responding!

When Do Students Do HW? -2003



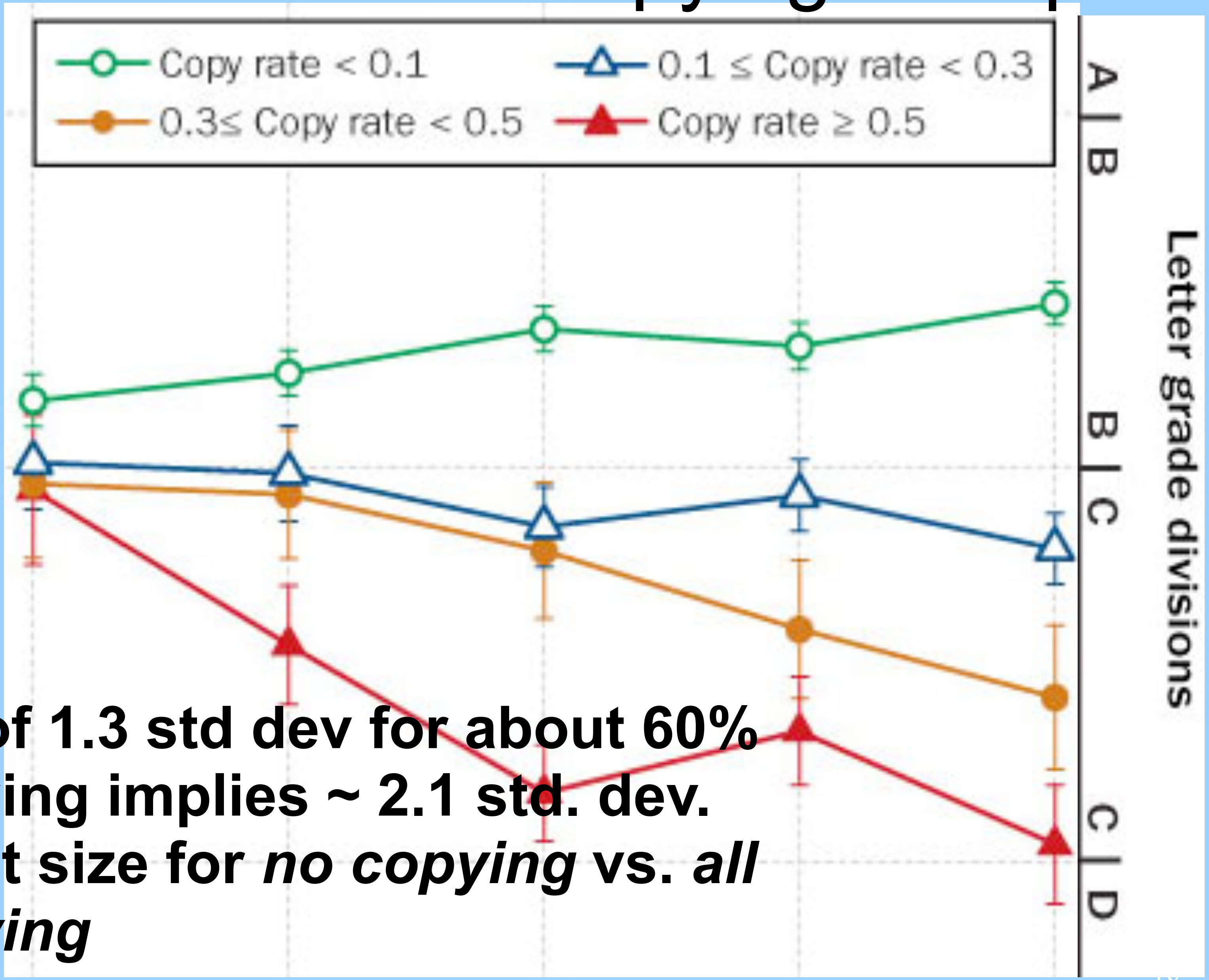
Detect Copying ← Quick, Correct Answer



Warnakulasooriya, Pallazo and DEP
J. Exptl Anal Behavior
***88** 103-113 2007*

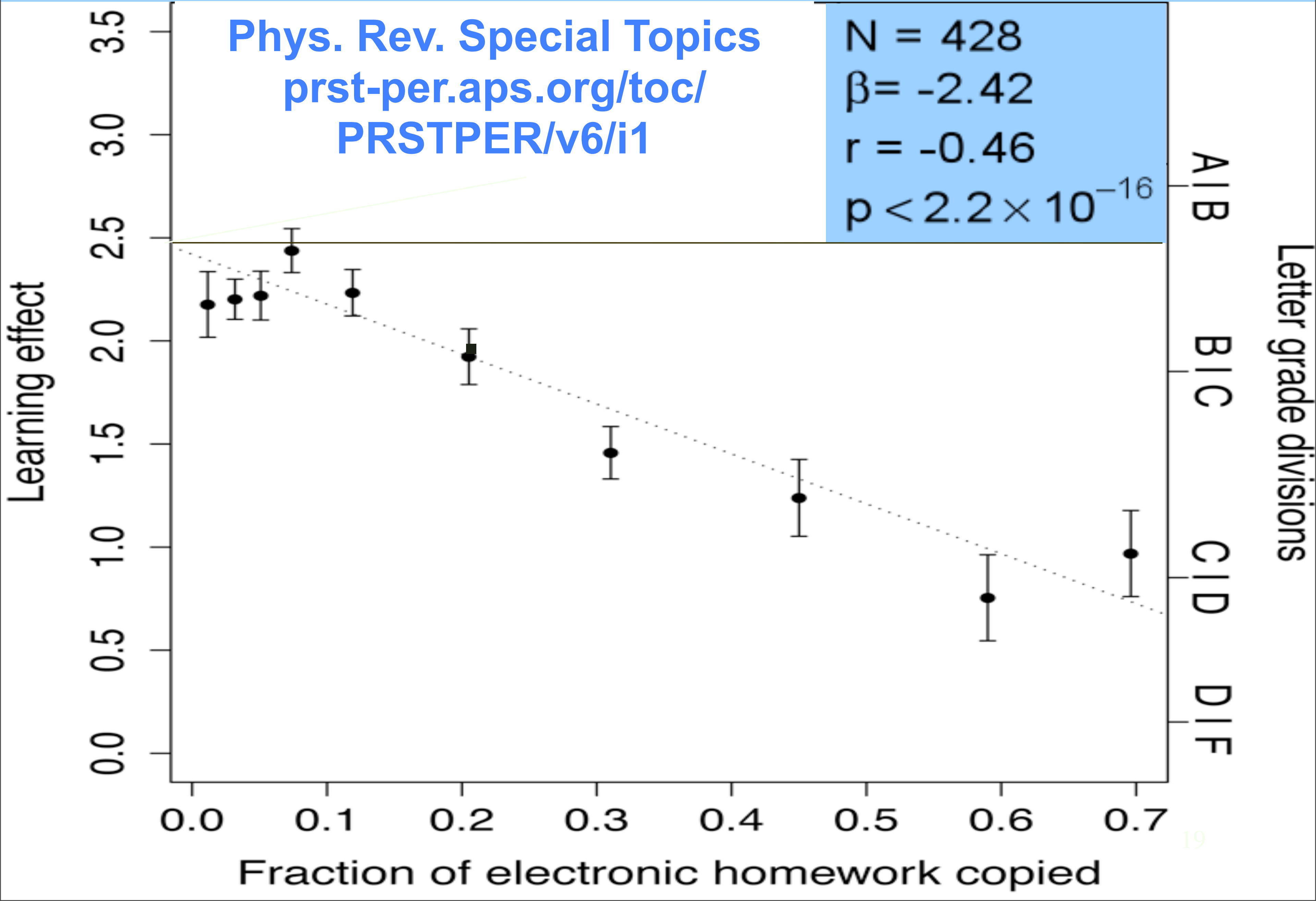
1. Respond in <1 min – insufficient to read and answer
2. Correct on first try vs. 90% of remaining students

Test Scores of Copying Groups

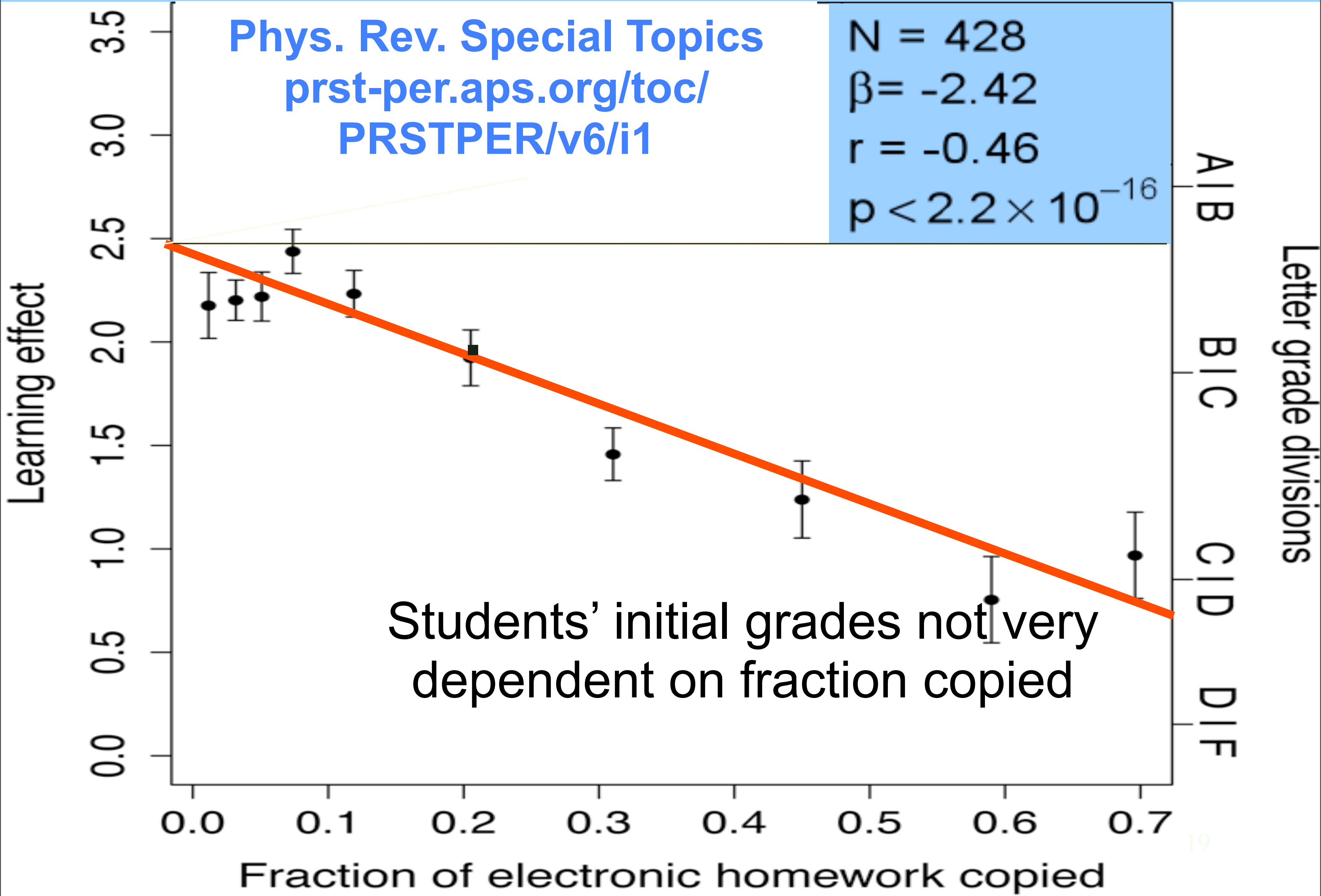


Net of 1.3 std dev for about 60% copying implies ~ 2.1 std. dev. effect size for *no copying* vs. *all copying*

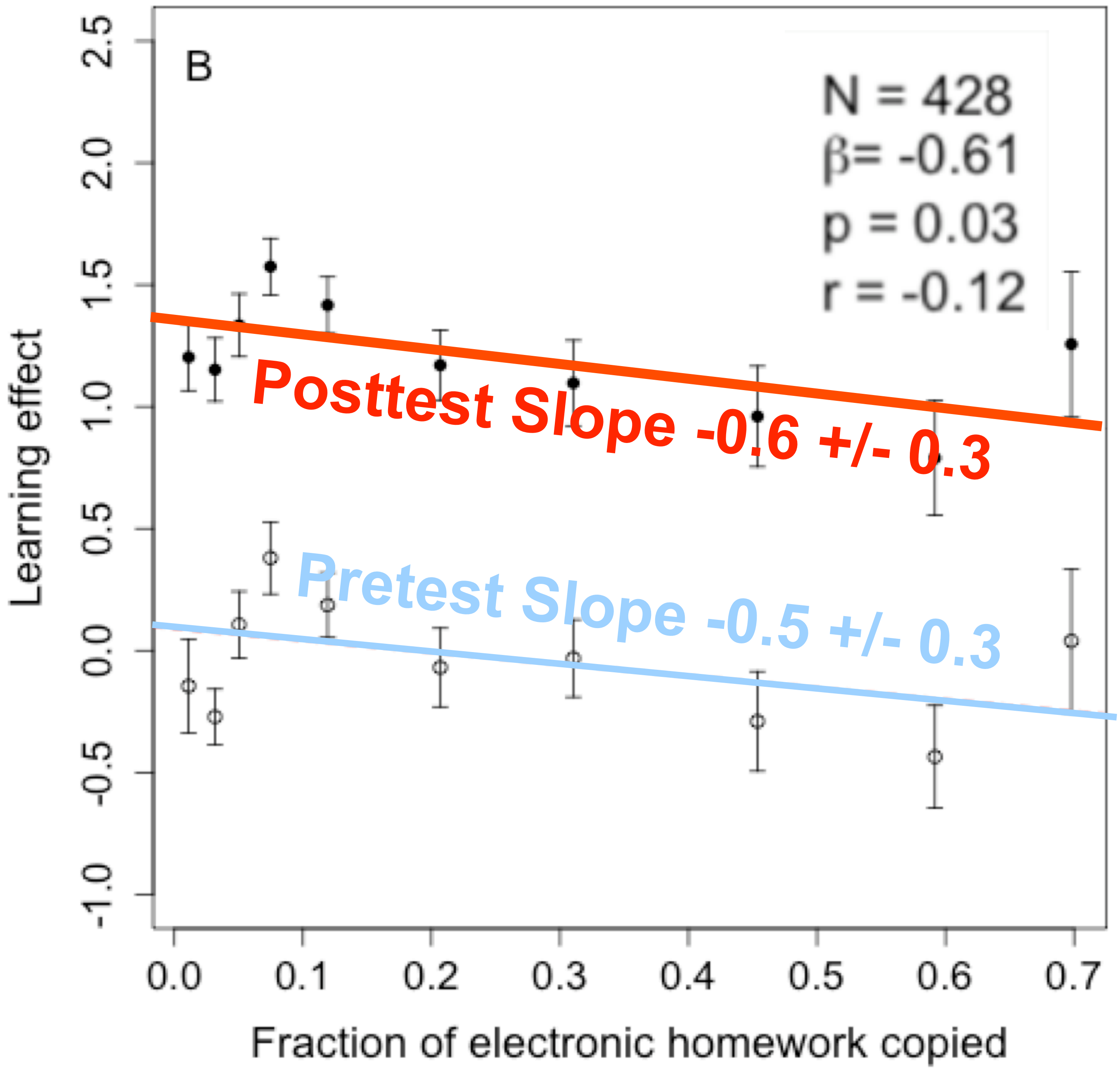
Analytic Final Exam vs. Copying



Analytic Final Exam vs. Copying



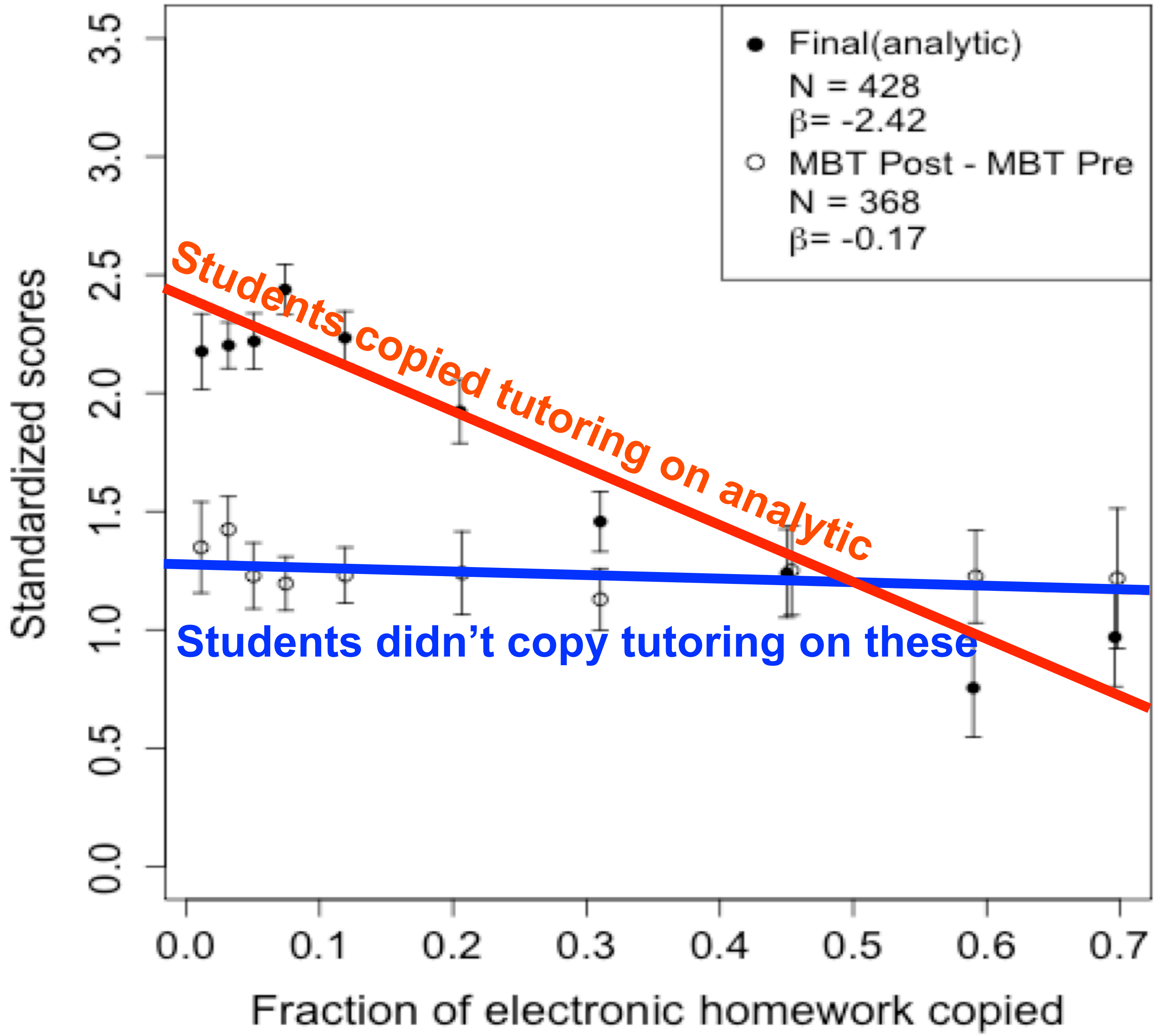
Dependence of Concept on Copying



Copying has insignificant correlation with Gain on ConceptTest.

Copiers and Non-copiers both have learning effect ~ 1.2

Copying Analytic HW degrades analytic score



Implications of Differential in Correlation

- **Amazing correlation with single activity**
- **MBT learning (concepts & numerical)**
  - **Independent of copying!**
  - **Shows copiers can learn physics**
  - **Strongly implies could learn analytic problems if they did Mastering**
- **Also implies Mastering teaches NO concepts or numerical skills**
- **Students Don’t Think Like Experts!**

A good habit: using hints first

MasteringPhysics.com (or any tutor) offers many possible paths for the student. Do some paths result in more learning?

Learning Effect of Various Paths

Y-J Lee, D. Pallazo and DEP
Phys Rev Sp. Topics Phys. Ed. Res. *2008*

(29% of all) Fail First Attempt

(11% of all) Go to Hint and Subtask

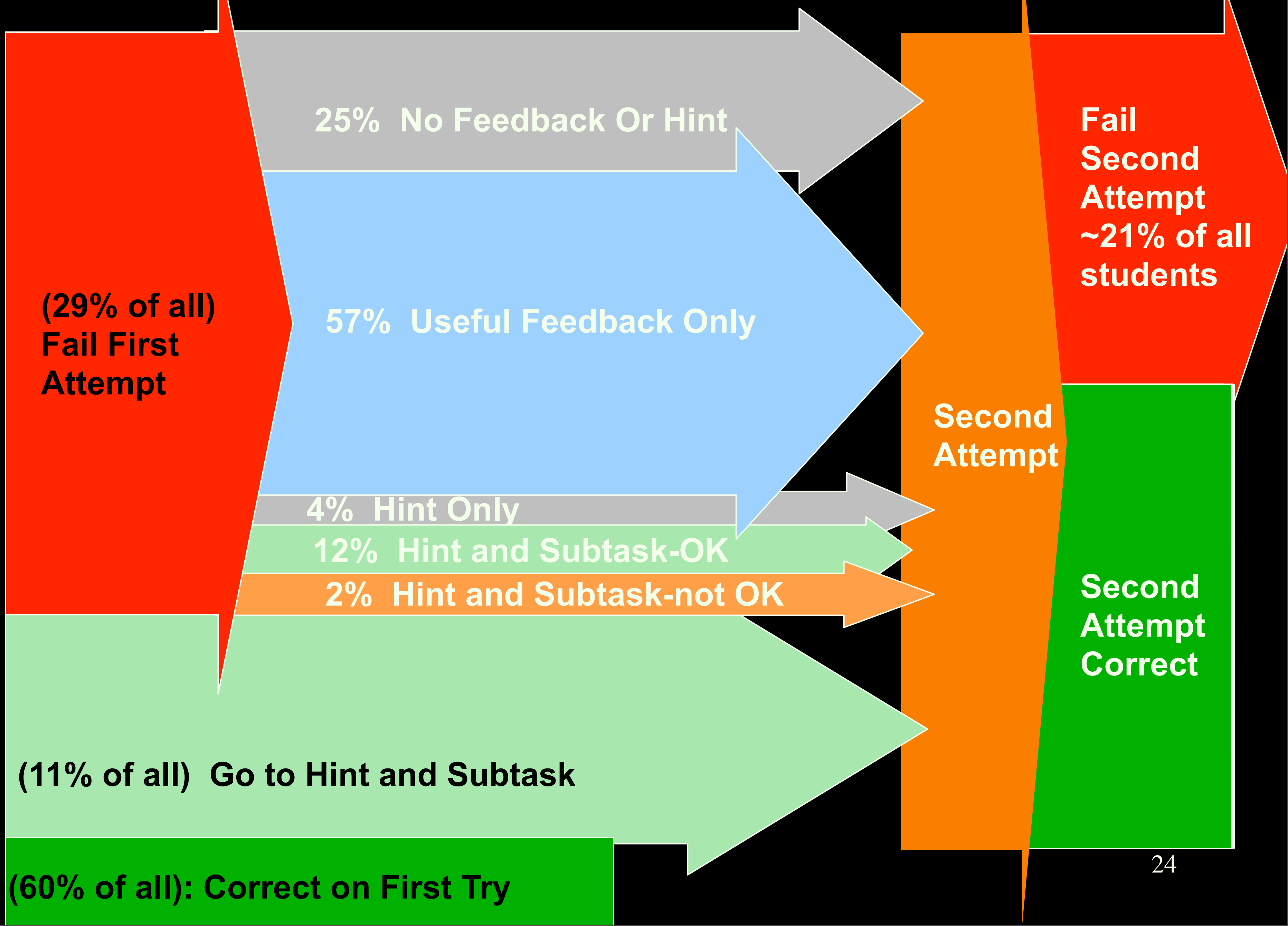
(60% of all): Correct on First Try

Second Attempt

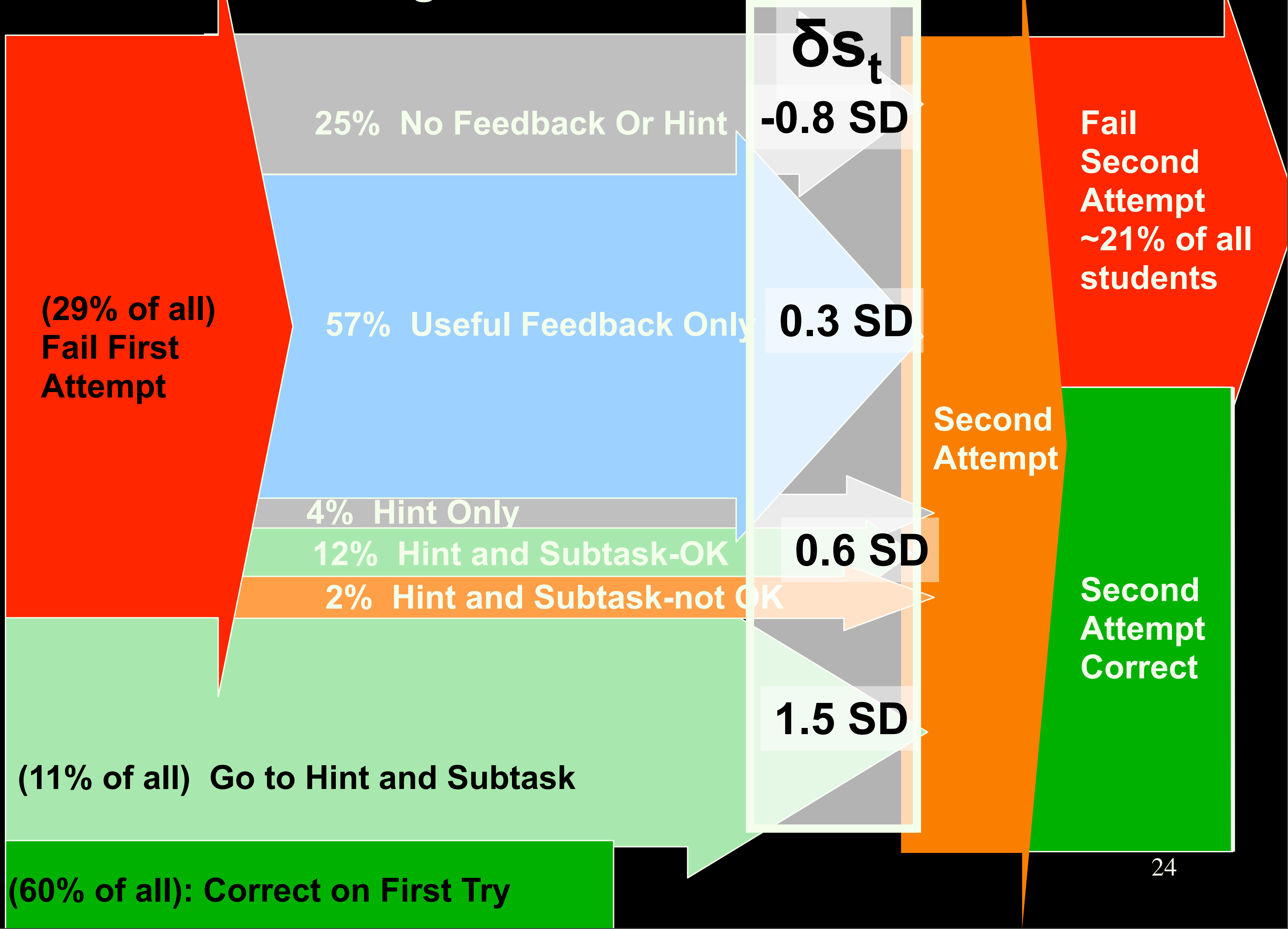
Fail Second Attempt ~21% of all students

Second Attempt Correct

Learning Effect of Various Paths



Learning Effect of Various Paths



Why is Hints-First so Beneficial?

- Metacognitive Monitoring of Own Knowledge?
  - Know they don’t know how to solve
  - Use hints until they know they do know how to solve
- Observation: Not same students each time
- We’ll have to do more research!

Outline

- 1. What they learned from (online homework)
- 2. What A- students learned that C didn't (4x)
- 3. Online Socratic Tutor used for Data Mining
- 4. HABITS
  - Copying (bad)
  - Requesting help before guessing (good)
- Now: what do graduating students retain of Physics 1
- Do we engender the learning faculty or students want?
- A Course that teaches Problem Solving Skills

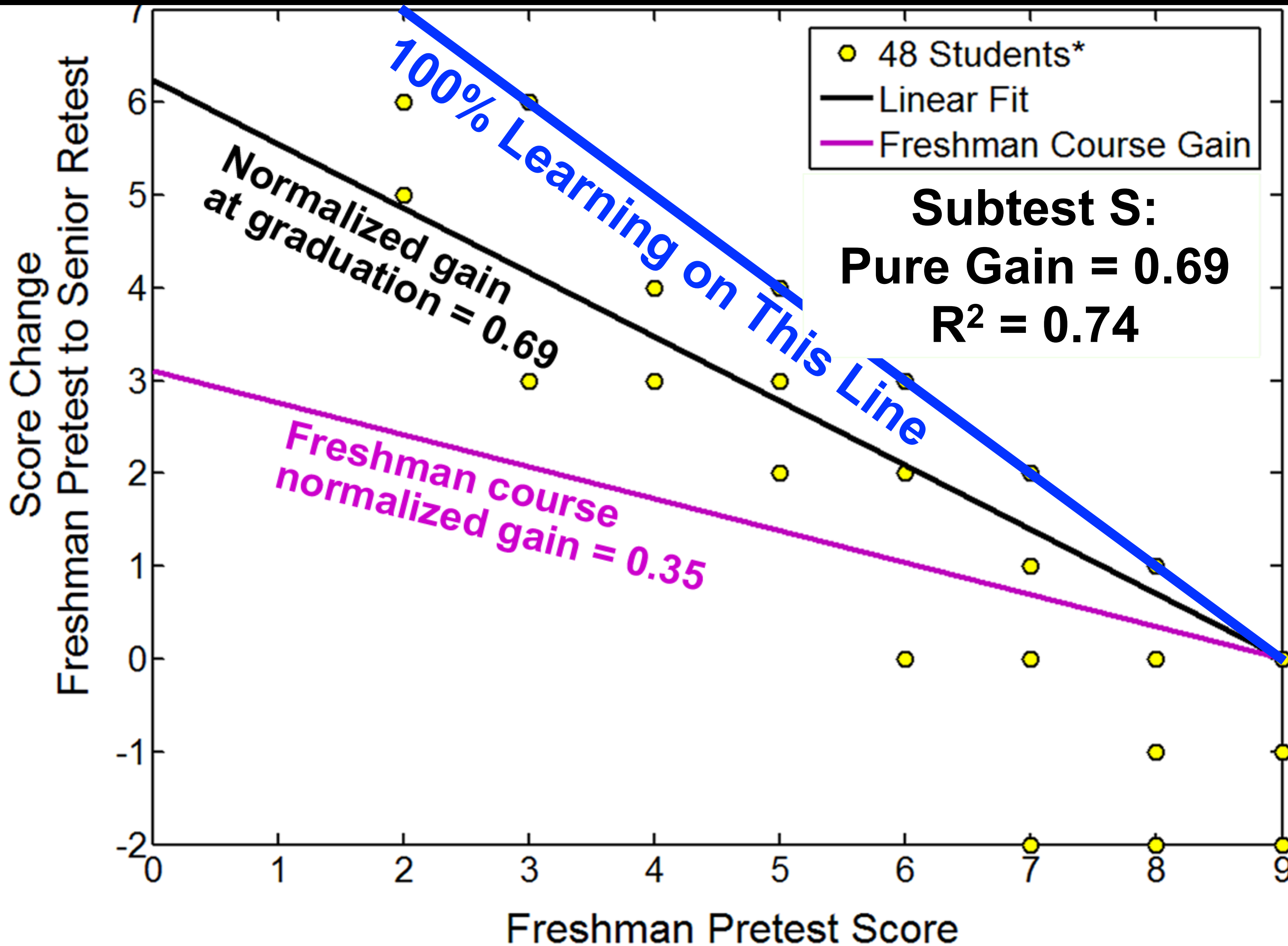
What Do Graduating Seniors Recall?

Do they remember our wisdom??

Expect users of mechanics (Gp 3)

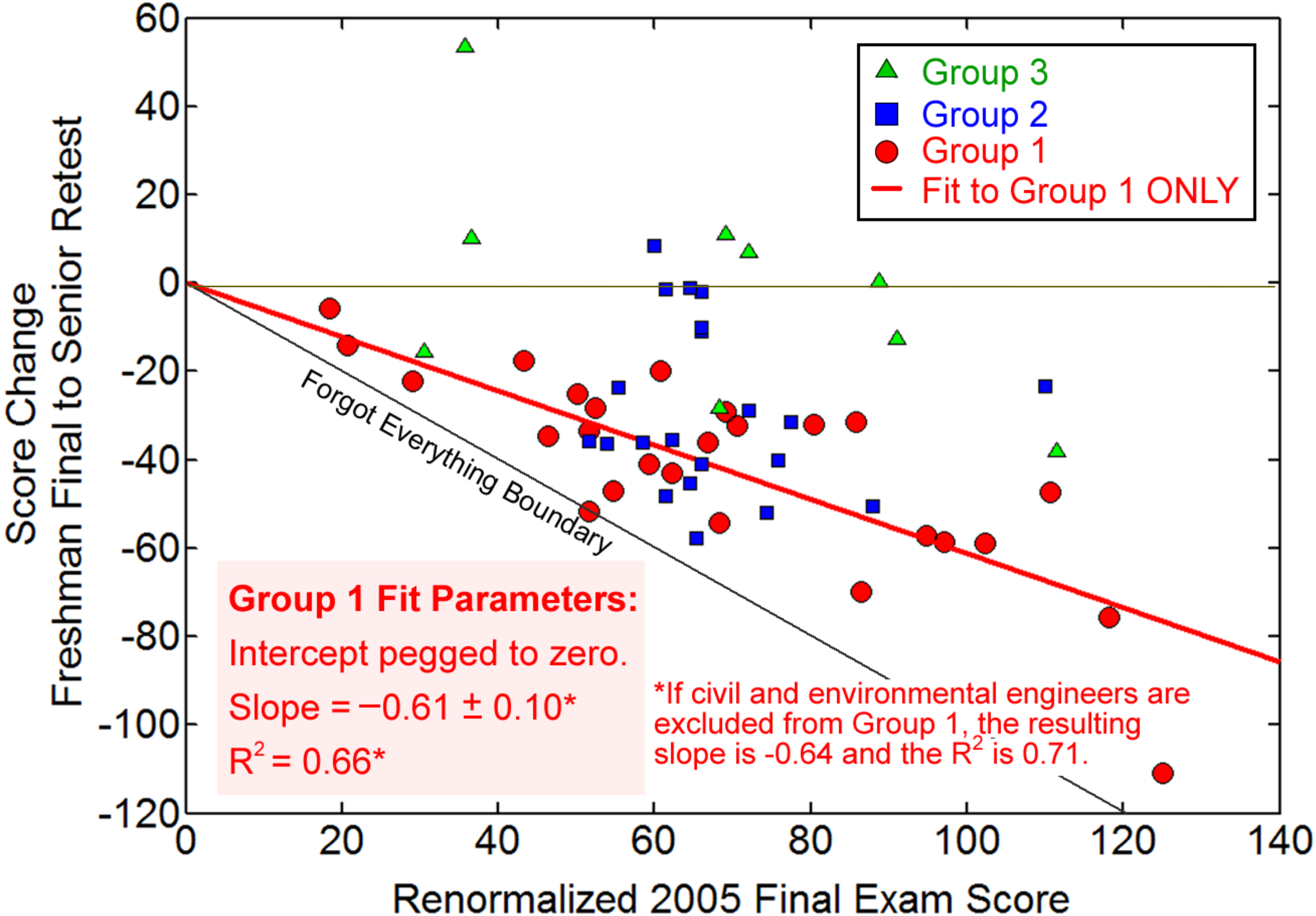
Group	Included Majors	N
Group 3 (Majors likely to use mechanics.)	Aeronautics and Astronautics, Mechanical Engineering, Physics	9
Group 2	Chemical Engineering, Economics, Electrical Engineering and Computer Science, Materials Science and Engineering	21
Group 1 (Majors unlikely to use mechanics.)	Biological Engineering, Biology, Brain and Cognitive Sciences, Civil and Environmental Engineering, Literature, Management, Mathematics, Political Science.	26

Increased Gain on Subtest Math



* Freshman responses unavailable for 8 students (4 Group 1, 3 Group 2 and 1 Group 3).

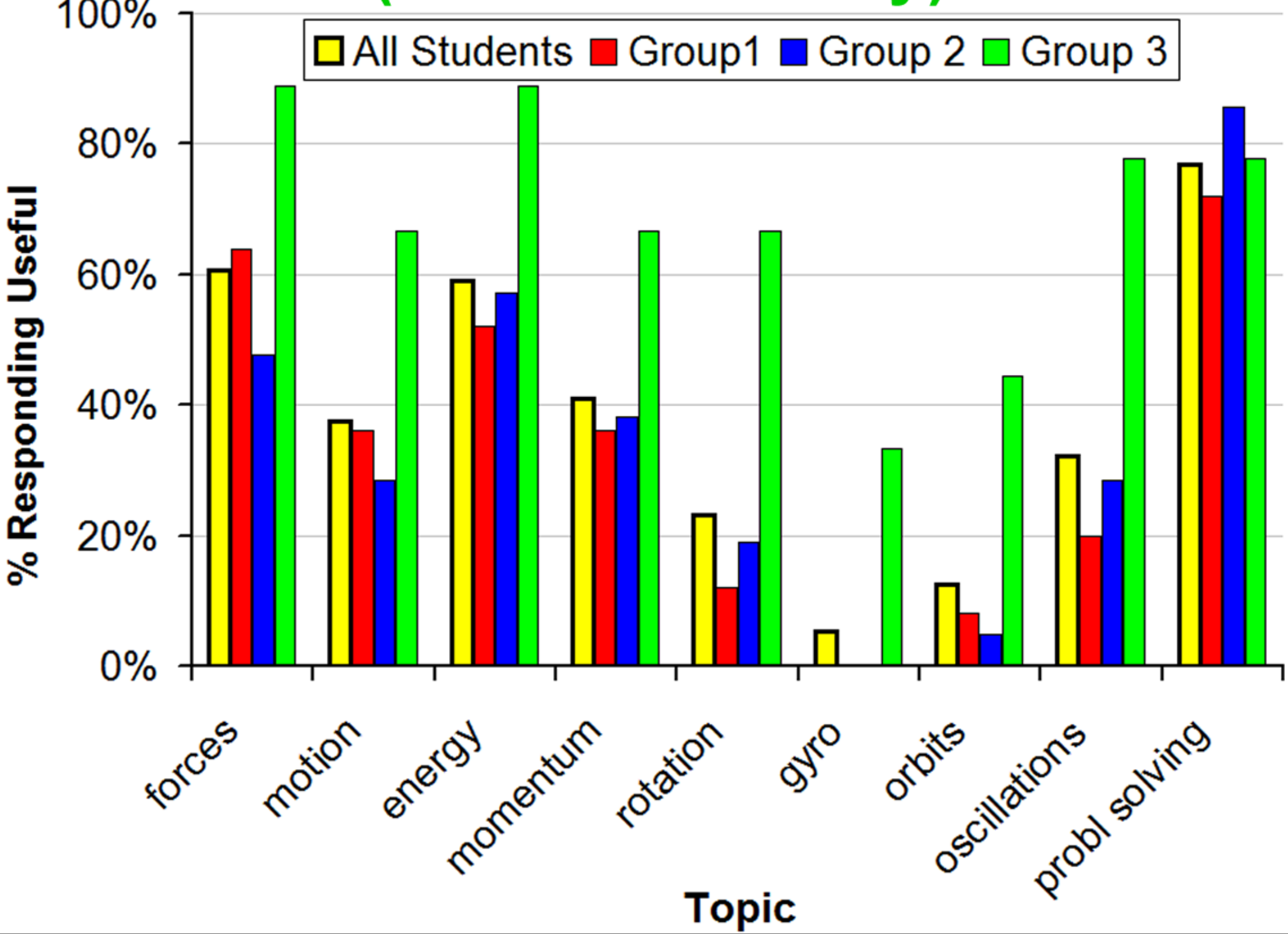
60% Lost on Analytic Final Exam Problems Among Group 1 Students



Types of Knowledge Re-Tested

Type of Problem		English Biology	Chem EE Mat. Sci	Physics M.E. Aero
Analytic Problems	Mostly two concepts, some requested Plan	−59(4)	−41(7)	−3(13)
Advanced Physics Concepts	Rotation, Oscillation, Orbits	−55(13)	−58(10)	−23(9)
Basic Physics Concepts (MBT)	Force, Motion, Energy, Momentum	−48(9)	−95(25)	−20(44)
Graphs & Vectors (MBT)	Reviewed in Math & Physics	+68(5)	+74(14)	+68(14)

Perceived Utility of Topics by Group (from MIT Survey)



What To Teach in Introductory Physics

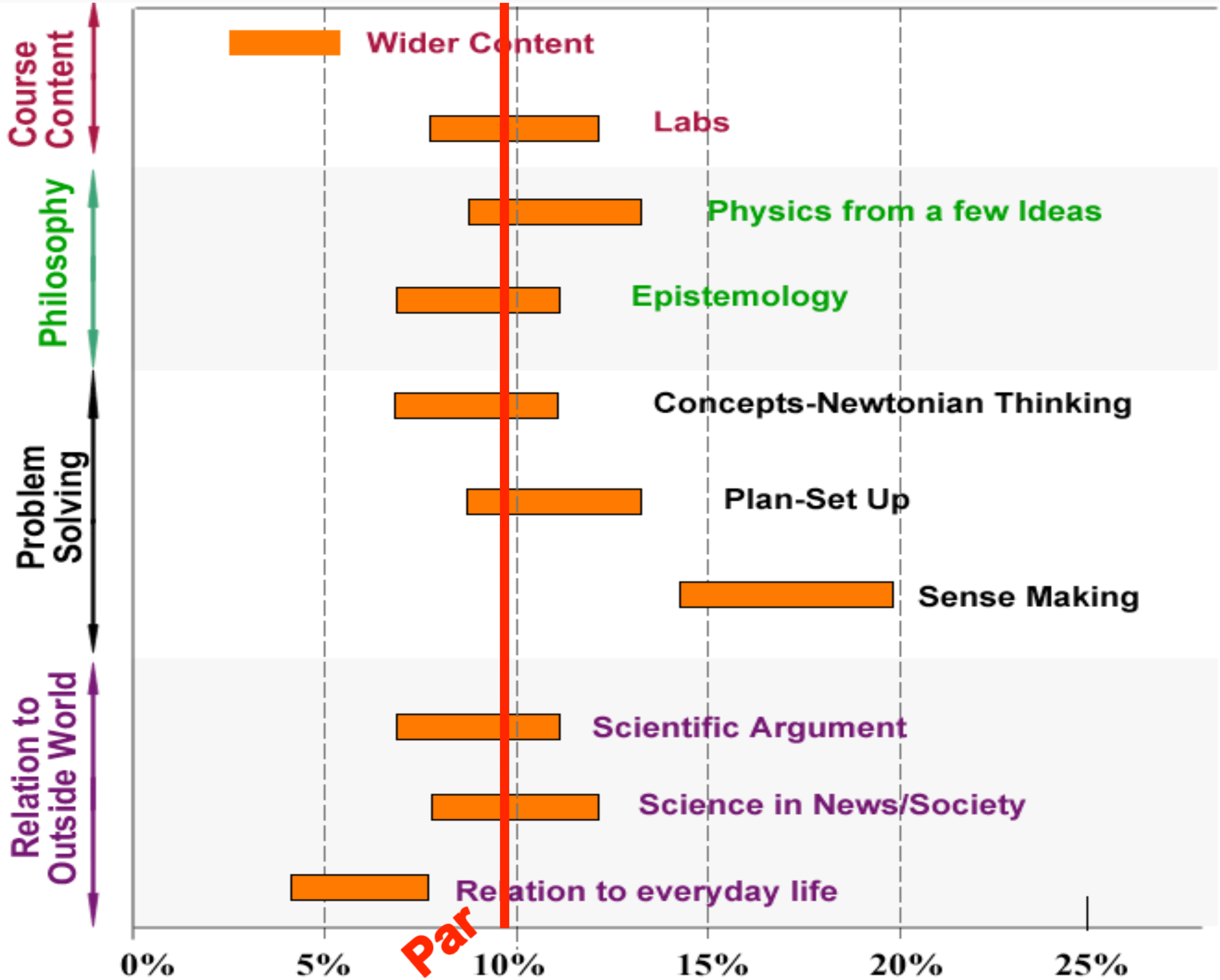
David E. Pritchard, Analia Barrantes, Brian Belland

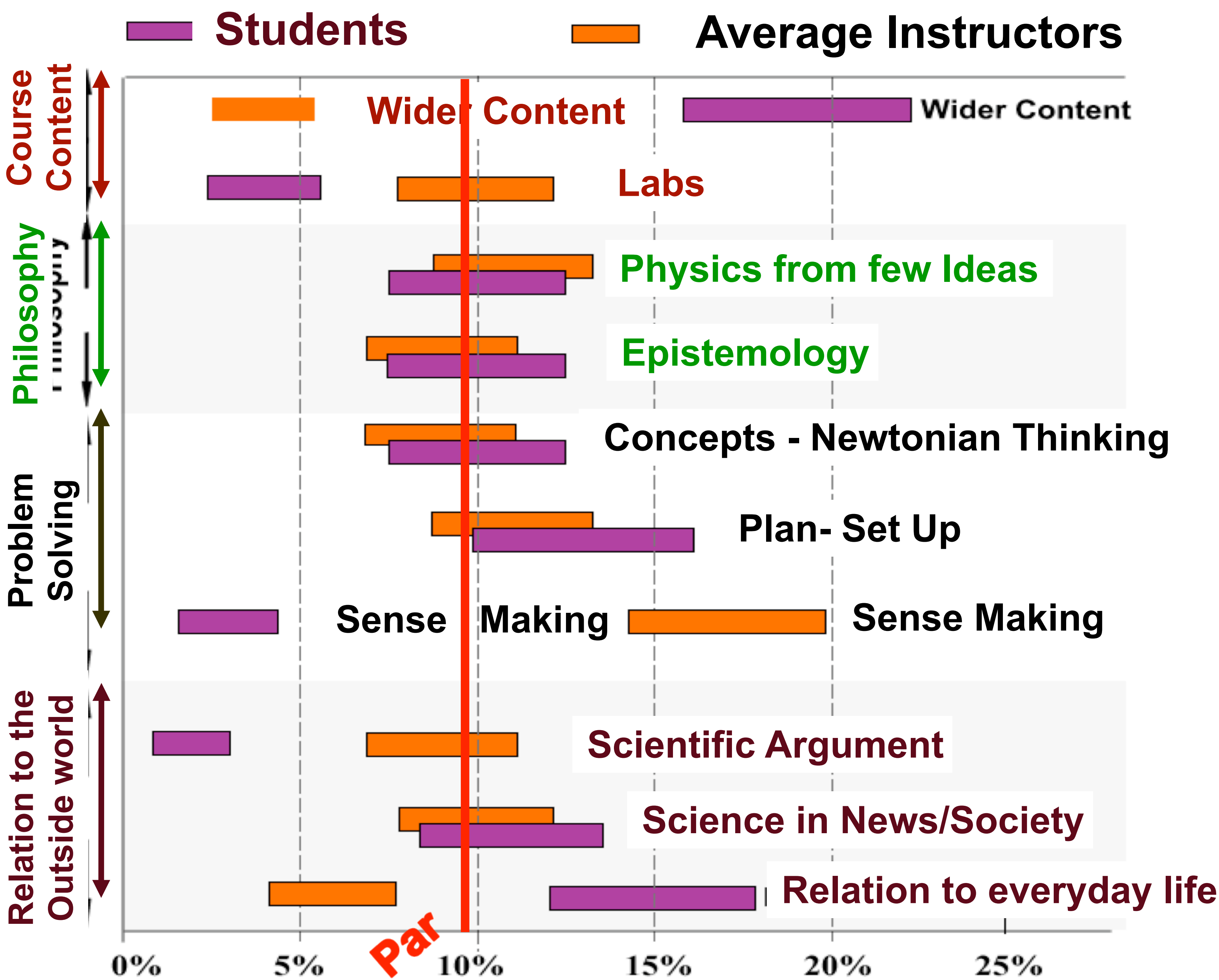
CONCERN: Before working more on education reform, I wanted to be sure of what teachers wanted to teach besides the syllabus

PROCEDURE: Asked people, especially AAPT/PERC
Distilled Free Responses down to ~12 responses in 4 categories

MY QUESTION: Due to a change in the academic calendar, you have 20% more time to teach the calculus-based introductory physics course to non-physics majors, and the syllabus has not been expanded. What learning will you seek to add or emphasize with this extra time?

~700 Instructor Votes





Students
Average Instructors
Course Content
Wider Content
Wider Content
Labs
Philosophy
Physics from few Ideas
Epistemology
Problem Solving
Concepts - Newtonian Thinking
Plan- Set Up
Sense Making
Sense Making
Relation to the Outside world
Scientific Argument
Science in News/Society
Relation to everyday life
Par
0%
5%
10%
15%
20%
25%

Professors vs Students (r=-0.4)

- Catalog says College will turn students into Lifelong Problem Solvers
- Professors “Welcome to college where we’re going to turn you into expert professionals and problem solvers”
- Catalog says freshman year is for exploration after which students are able to pick any major
- Students “I’m looking for a major, show me why physics is relevant to my interests and life. Then I might invest 10+ years to become an expert!”
- → RECOMMENDATION: more attention to why intro physics is relevant to their futures.

Modeling Applied to Problem Solving

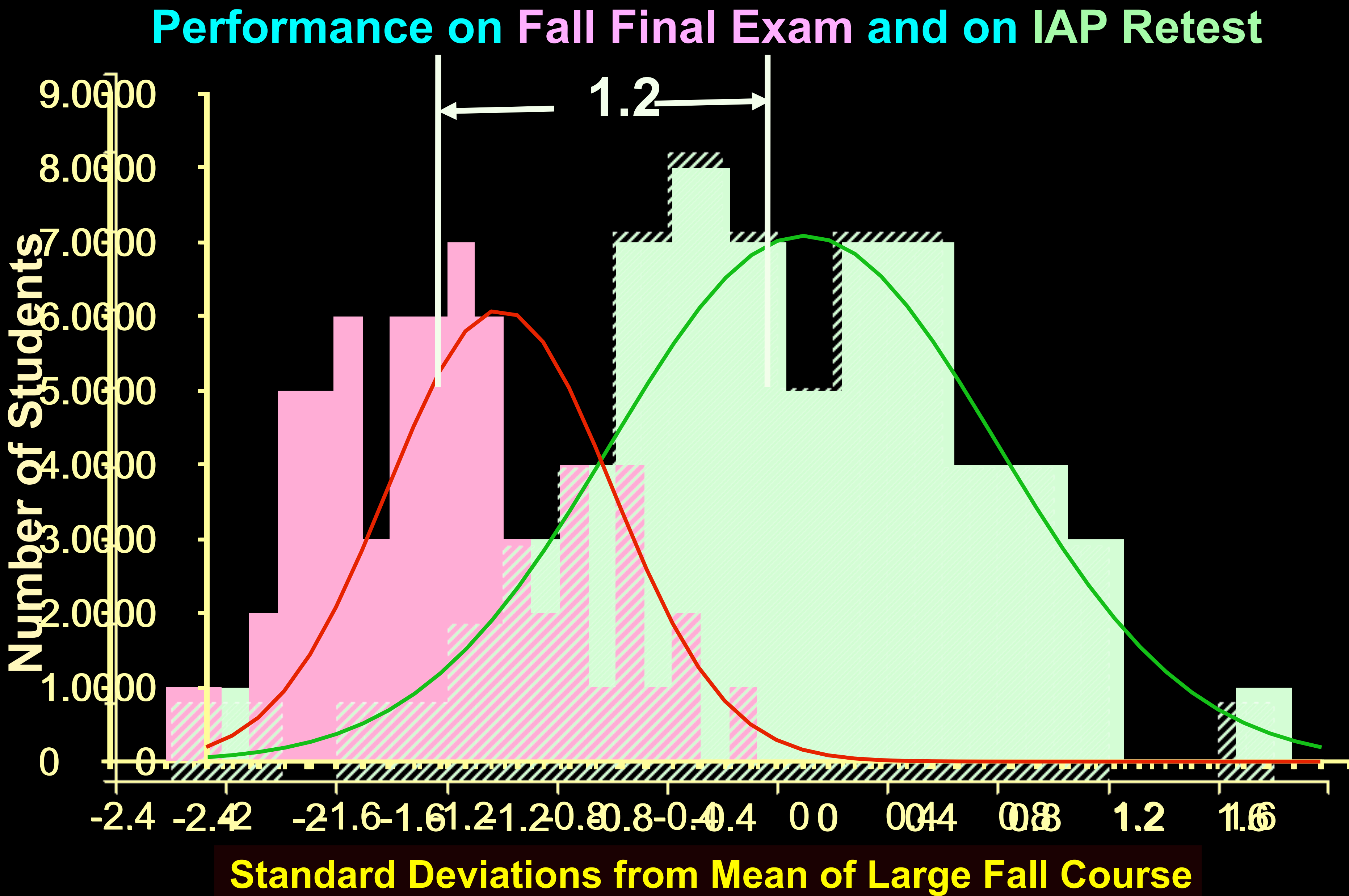
Frequent Problem (e.g. CLASS question)

After I study a topic in physics and feel that I understand it, I have difficulty solving problems on the same topic.

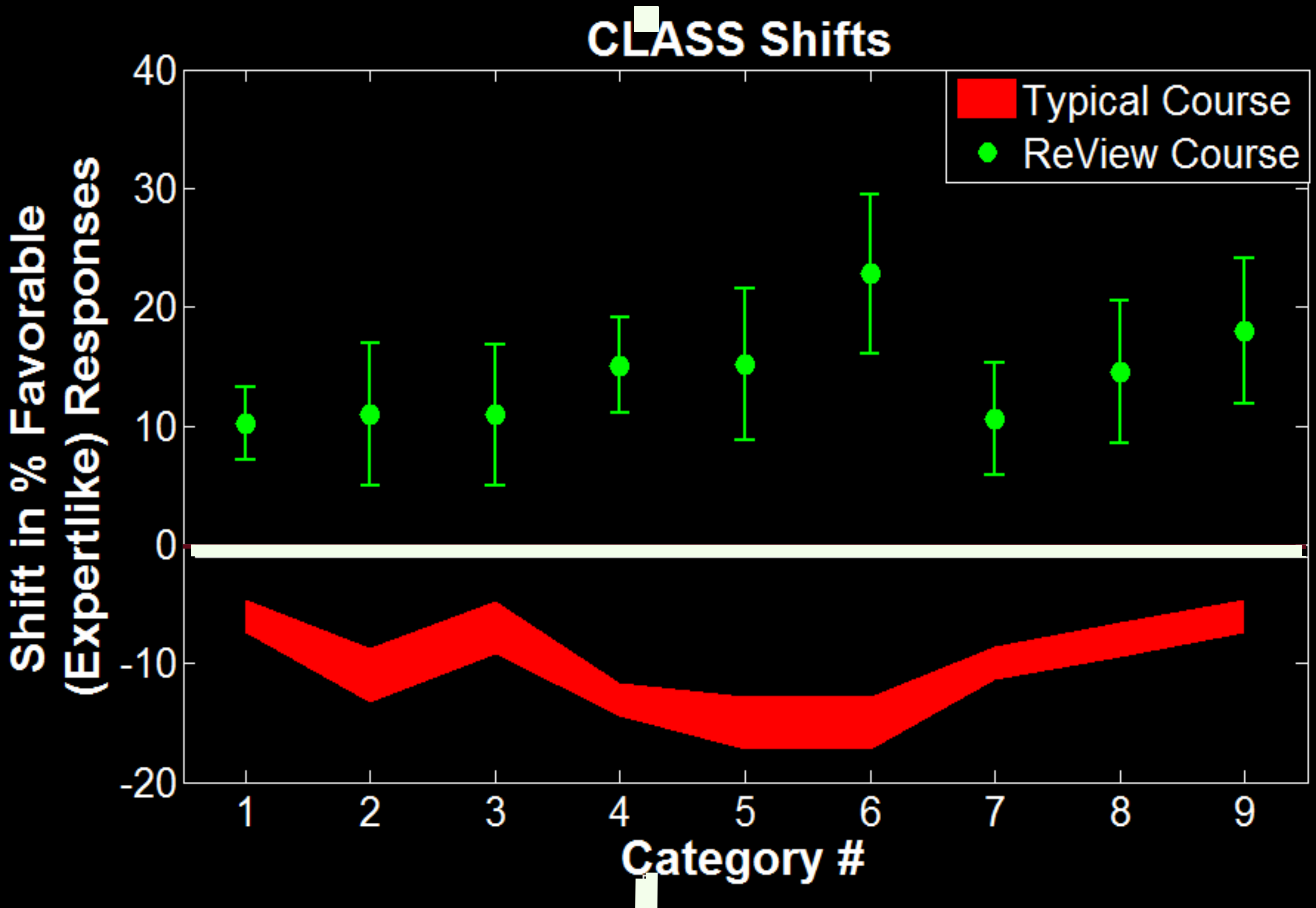
MAPS: Students Learn to Solve Problems

1. **Measurably better**
2. **In a more concept-based manner**
3. **With better organization of knowledge**
4. **With improved learning attitudes**
5. **With Transfer to future E&M course**

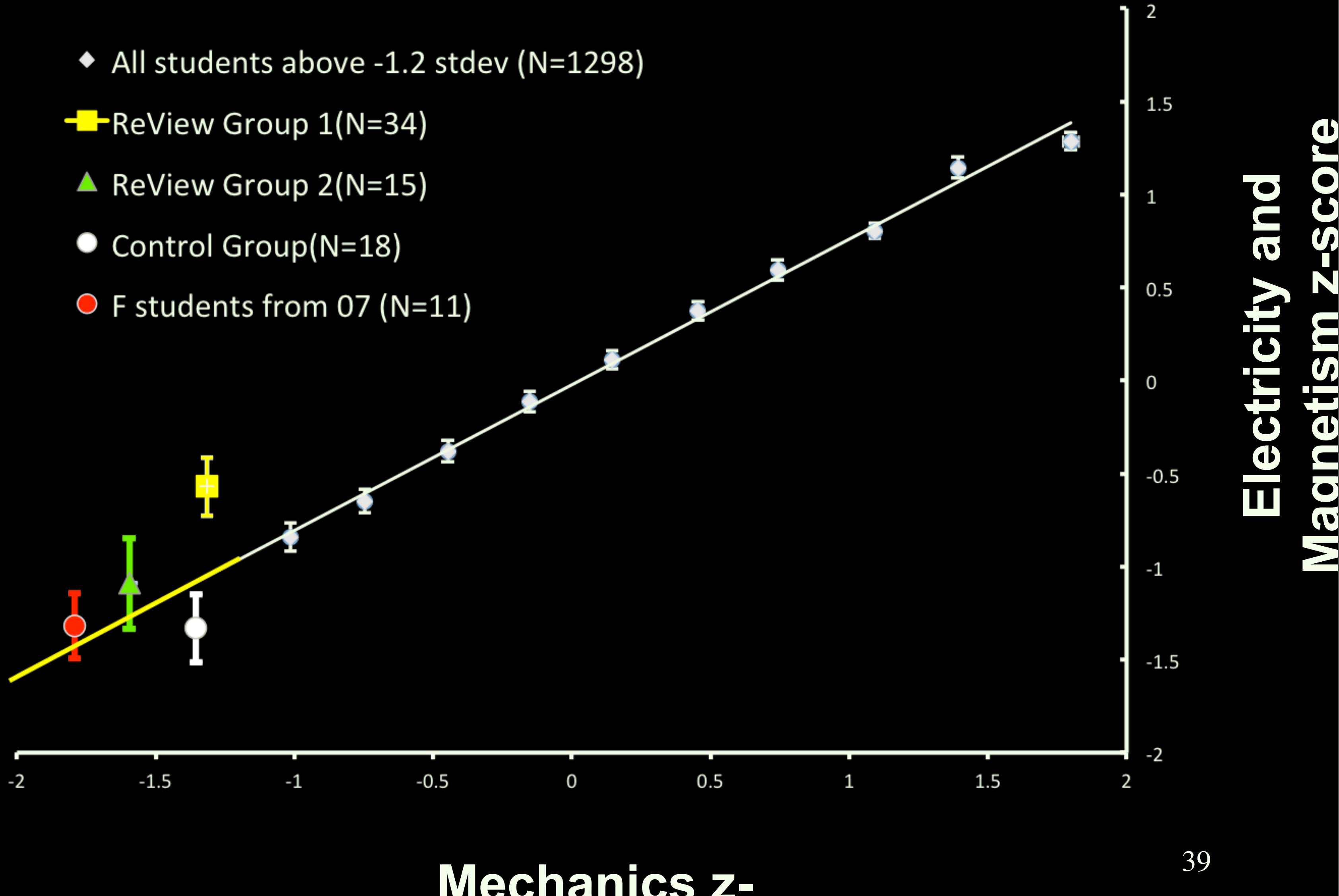
Improved Performance



Improved Attitudes



Transfer: Benefit in E&M from

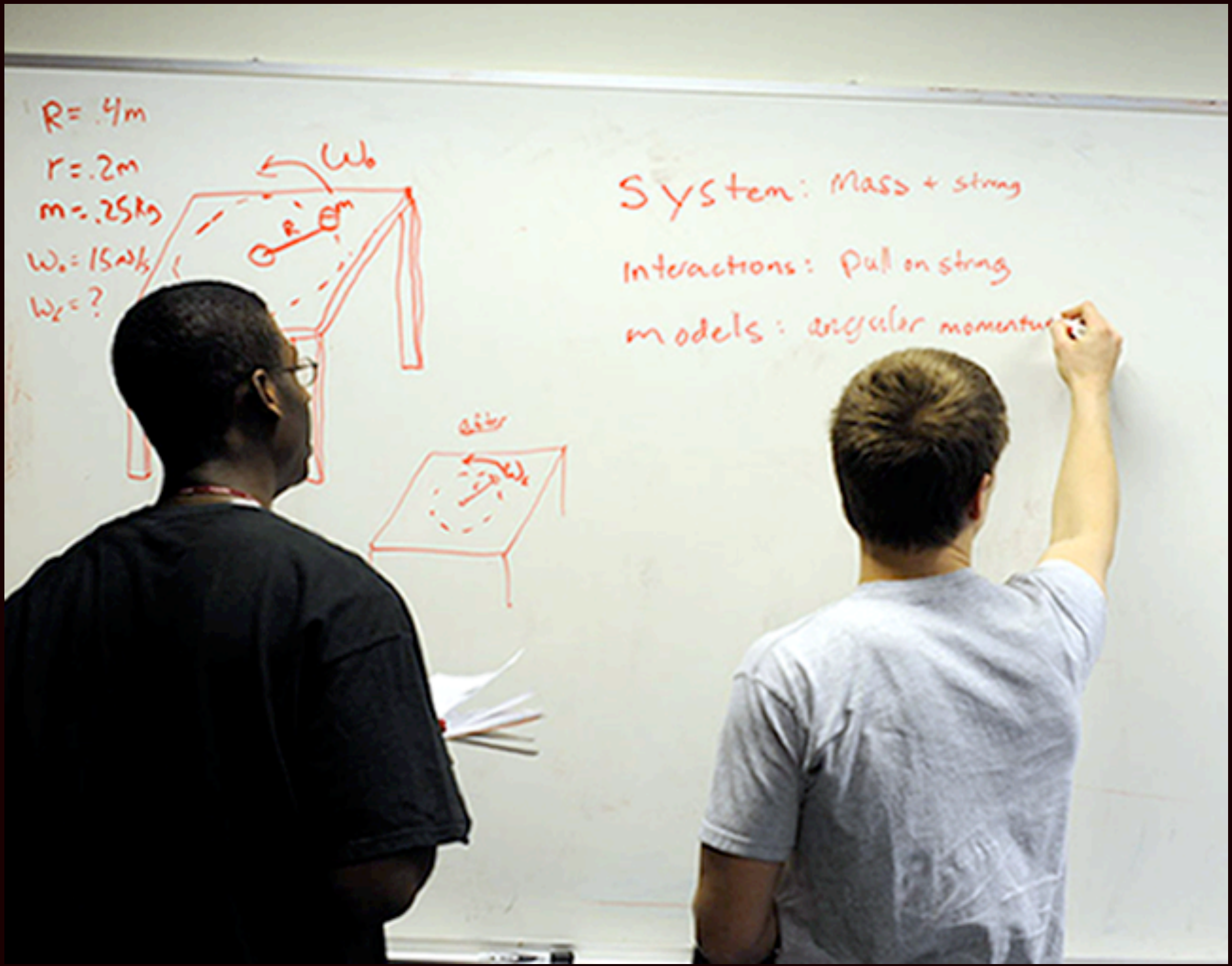


2.5 week ReView for D’s in Fall Phys 1

Students worked in groups of 2:

- Individual and On-Board Problem Solving.

-Table activities (4 students per table).



Take Home Lessons

- Partial Credit Grading Rewards Partial Understanding
- MasteringPhysics gives 2 sigma gain on analytic problems
- Homework Copying is Largest Anti-Learning Factor: you MUST and Can Reduce It!
- Seniors Used It or Lost It (~50% or more)
- What to Teach YOUR Students?

Digital Education Future?!

To age 16 in class	Lifelong Anytime/where
Teacher	Coach & Electronic Tutor
Teach a Class	Help Student Learn
Broadcast Radio	Two-way Radio
Passive	Inter-Active
Author	Authors/Researchers
High Stakes Tests	Integrated Assessment
Next Edition	Next Day

Education Improvement

Identify the problem or needed improvement

Plan (with committee?) approach

Modify instructional procedure/material

Survey Student and Staff Approval

Scientific Education Reform

Identify the problem or needed improvement

Plan (with committee?) approach

Modify instructional procedure/material

Survey Student and Staff Approval

Scientific Education Reform

Read the literature

Identify the problem or needed improvement

Plan (with committee?) approach

Modify instructional procedure/material

~~Survey Student and Staff Approval~~

Assess the Outcome

Rethink and Recycle

Publish the New Results