Detailed Studies of Learning

- Data Mining to study sources of Learning
- +/- paper
- Retest

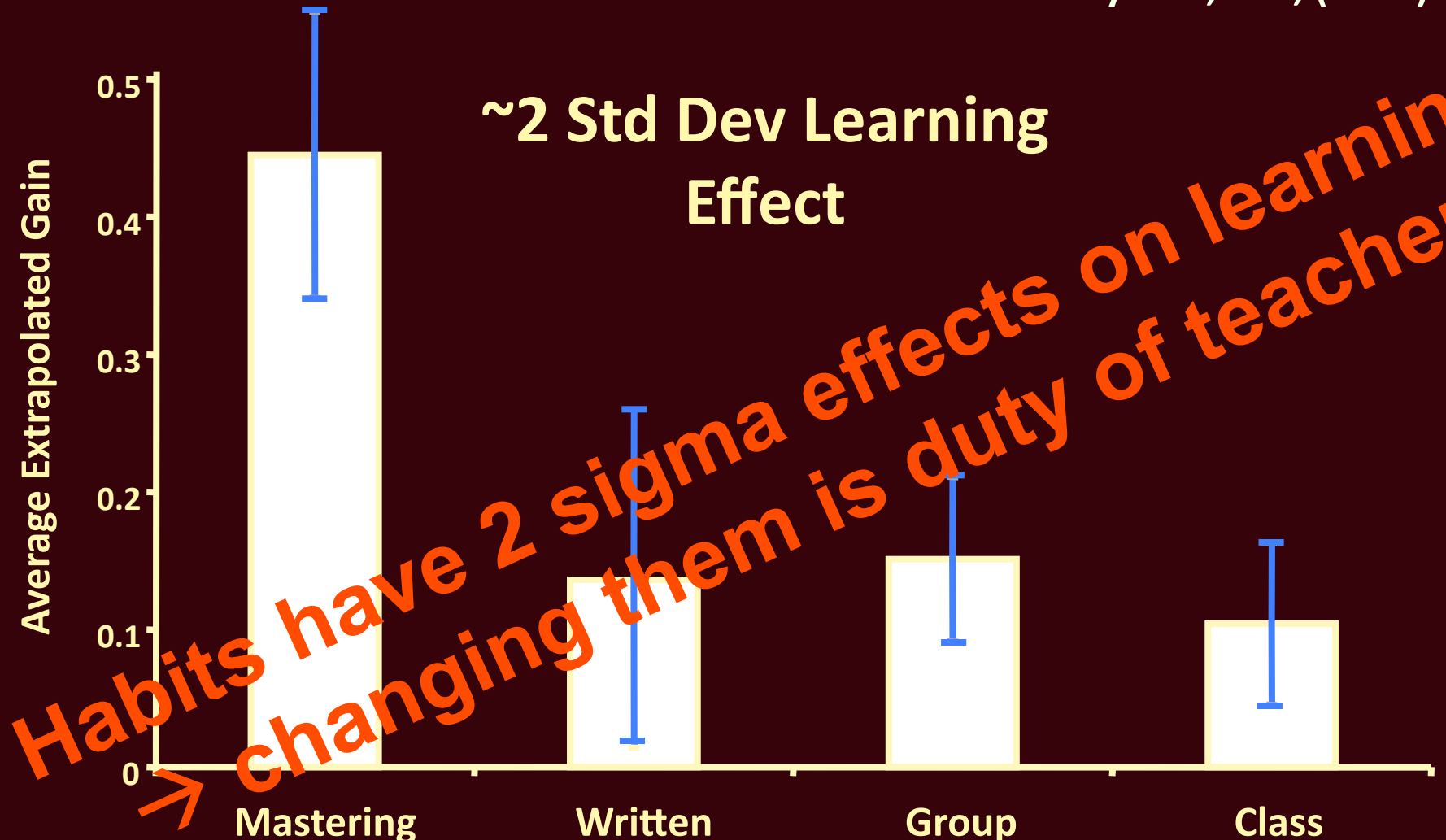
What Should They Learn?

ONLINE: Integrated Two Way Learning

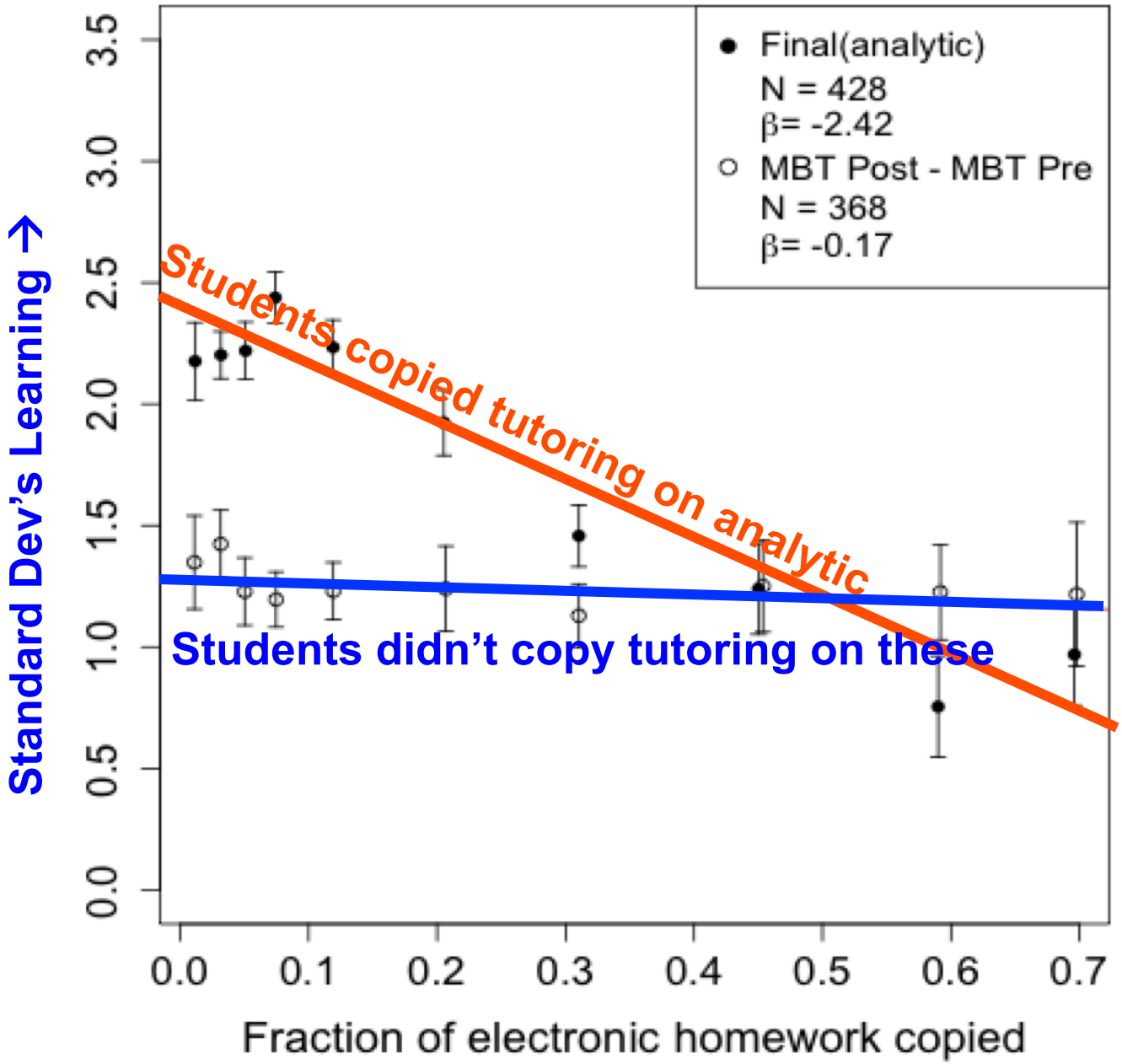
- Digital Age?!
- Various New Ideas

What Correlates with Learning in Remedial Course?

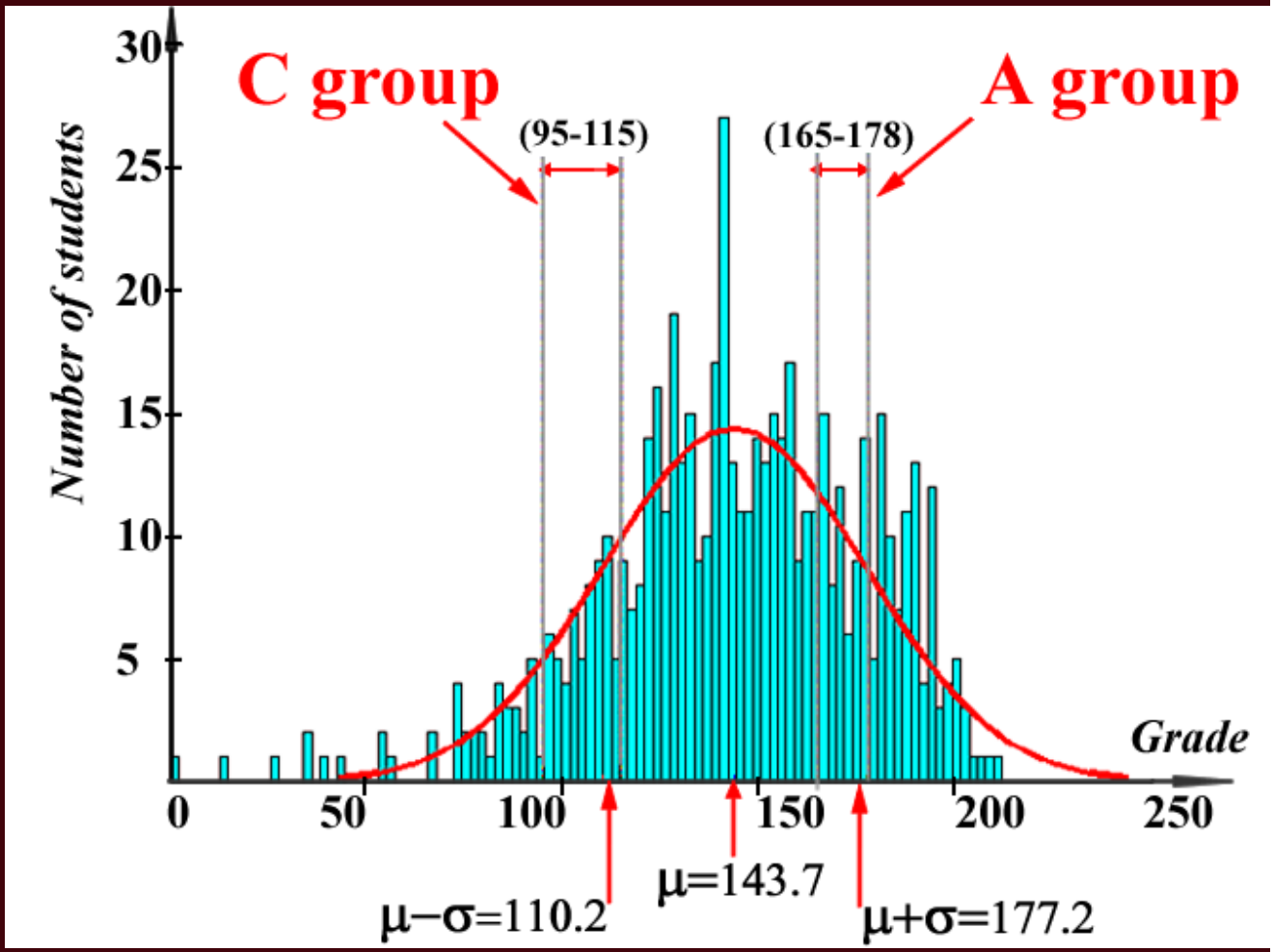
S-M. Morote & Pritchard Am. J. Phys. 77, 746, (2009)



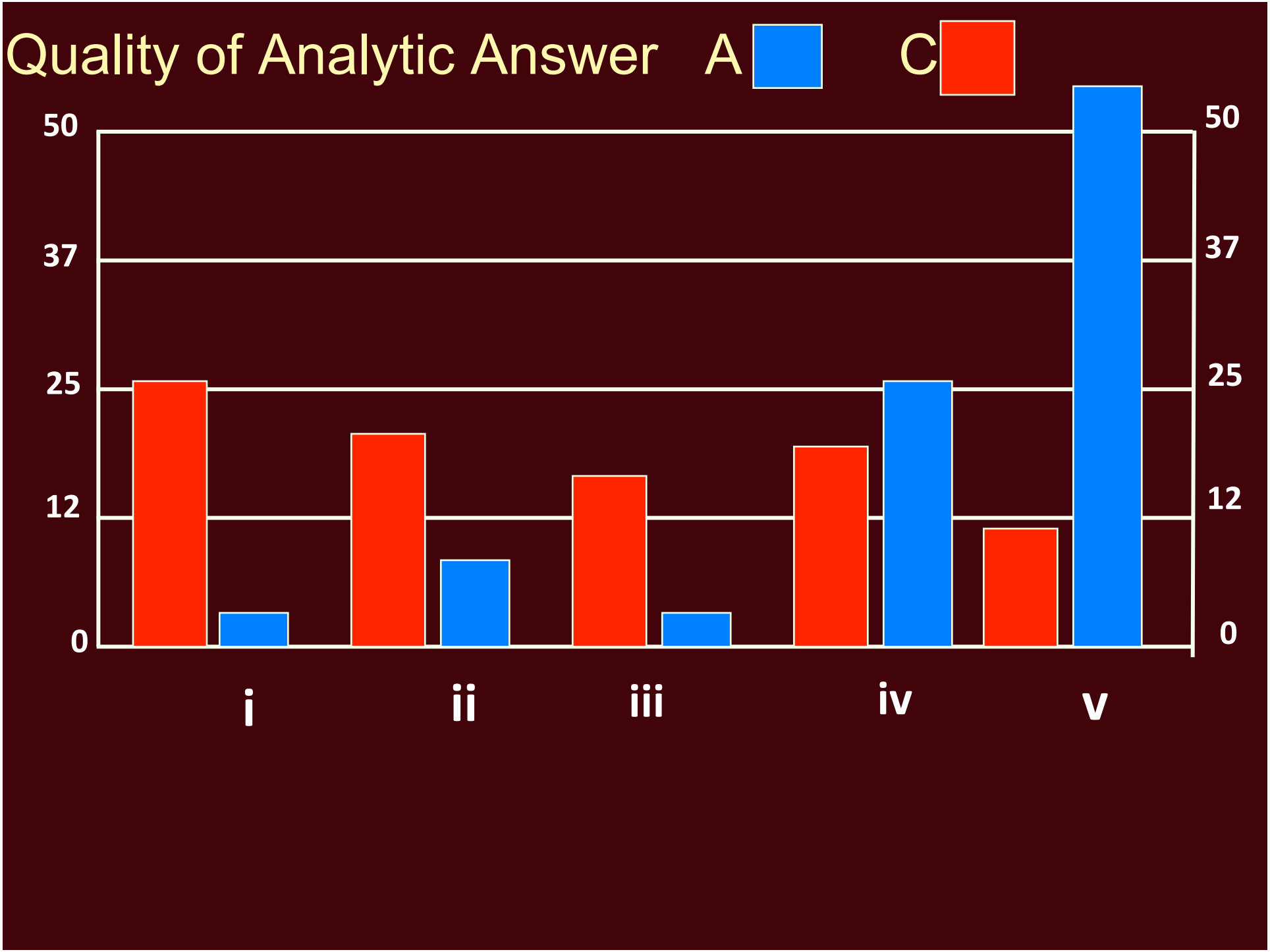
Copying Analytic HW degrades analytic score

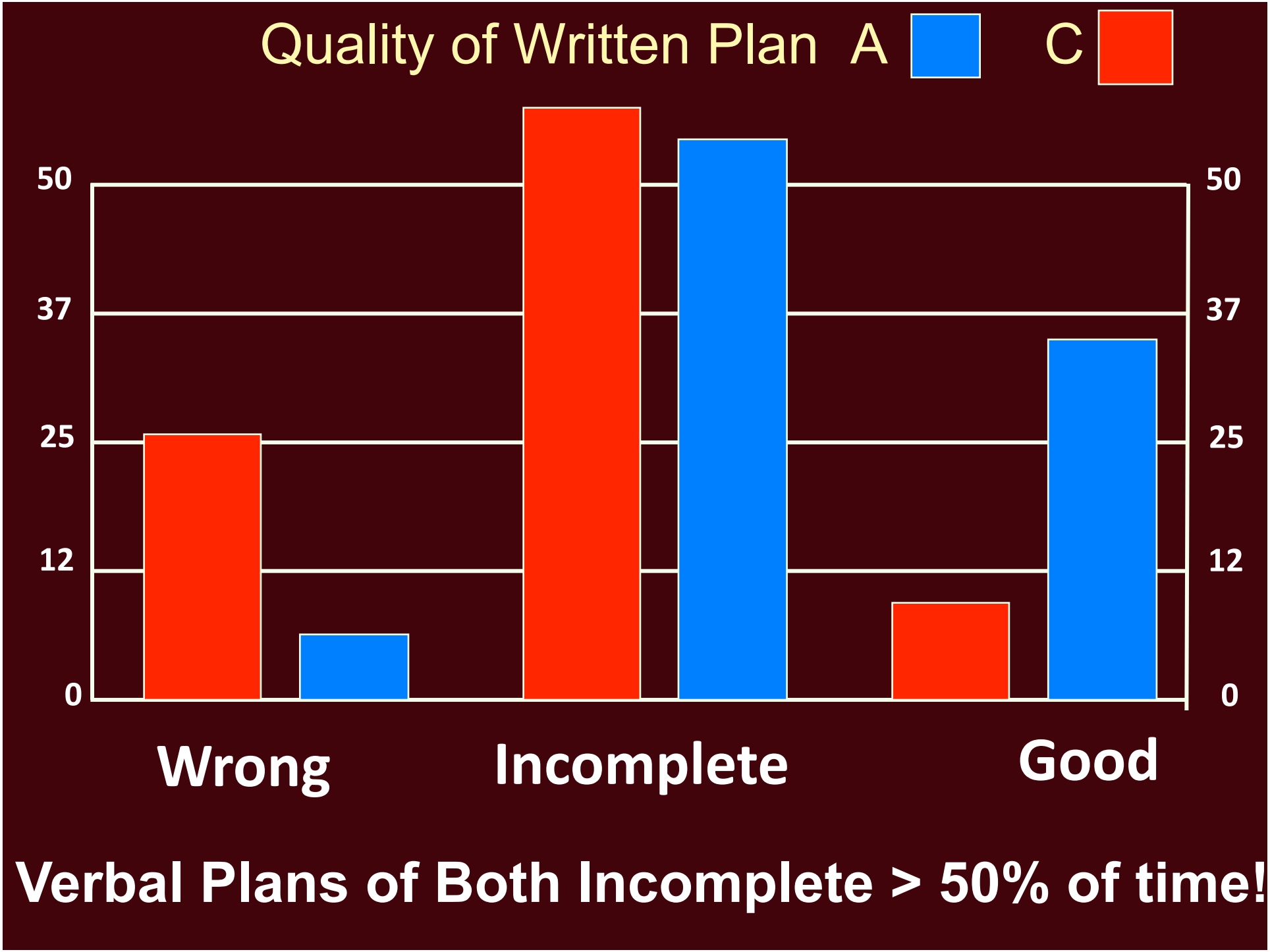


Usual Partial Credit Grading: 2 Sigma?



- What A students learned that C students didn't
- A- students (1 Sigma +): a reasonable expectation of what students should learn
- C students: those we pass without many reservations


Quality of Analytic Answer
A
C
50
37
25
12
0
i
ii
iii
iv
v



Verbal Plans of Both Incomplete > 50% of time!

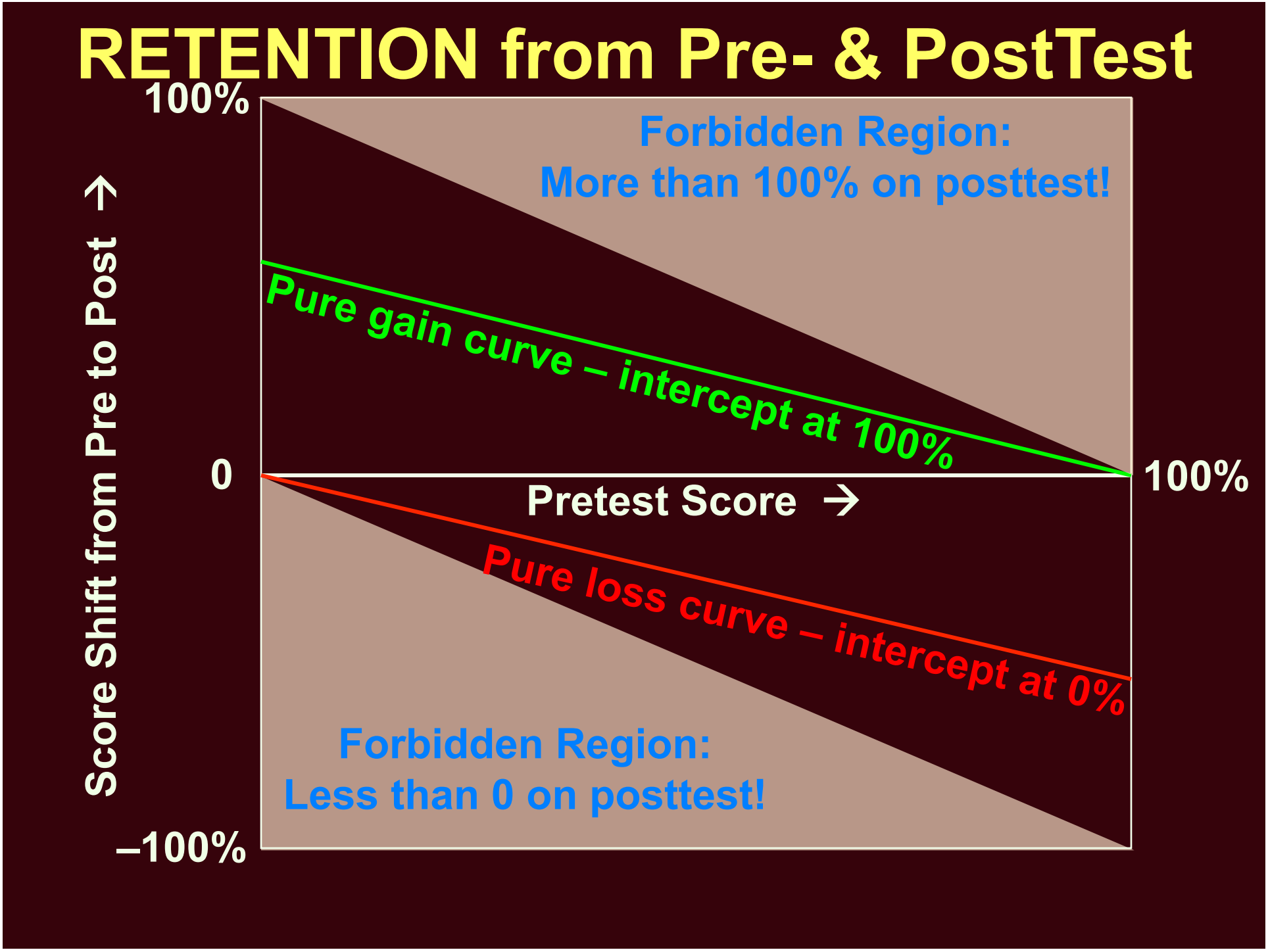
Conclusions on What's Learned

- **Note: Score of C's is 60% that of A's**
- **A's Good analytic or verbal 4x C's**
- **C's significantly wrong 4x A's**

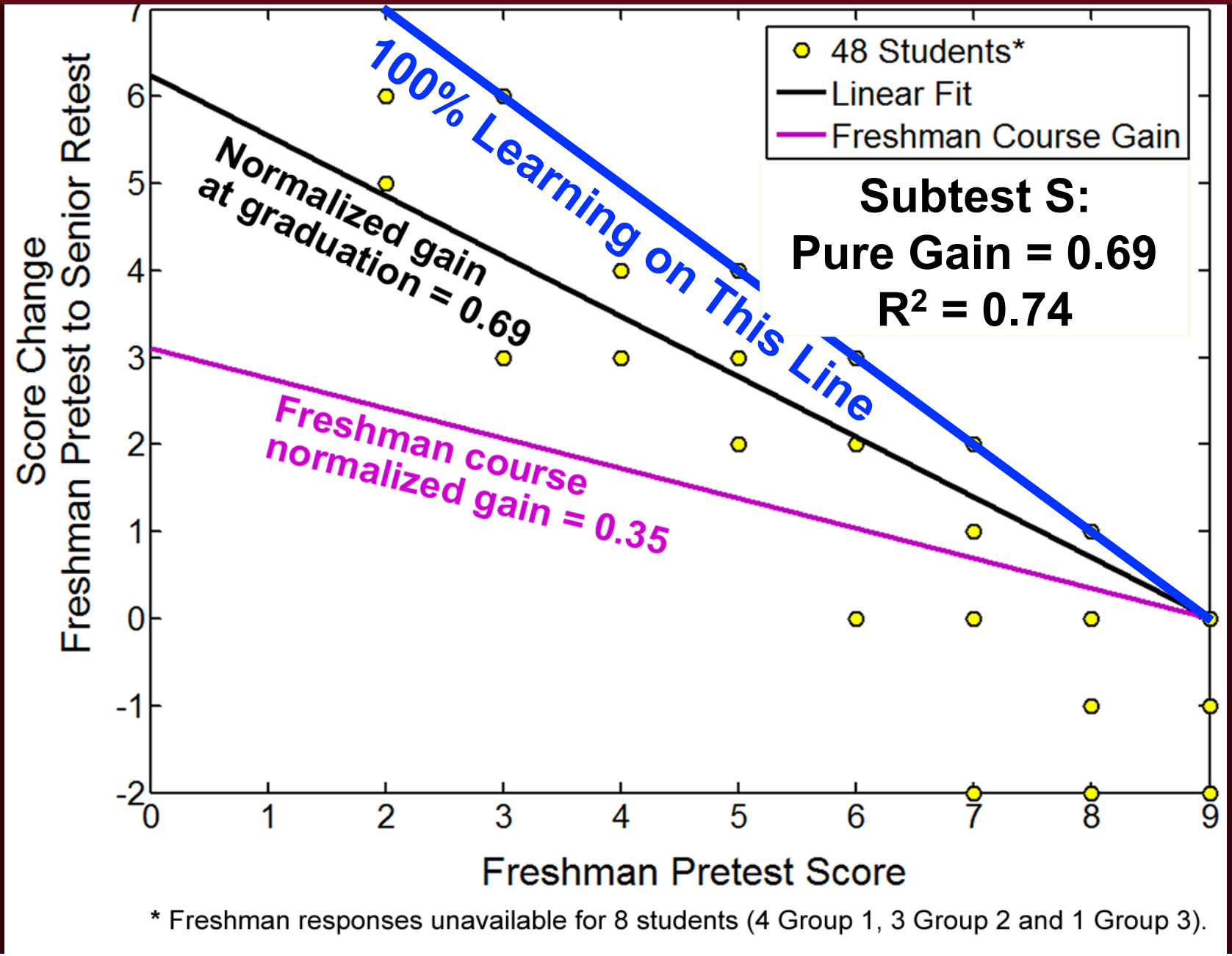
- **Partial Credit Grading**
- **Rewards Partial Understanding**

What Do Seniors Remember From Freshman Physics?

- Give them the same test and see!

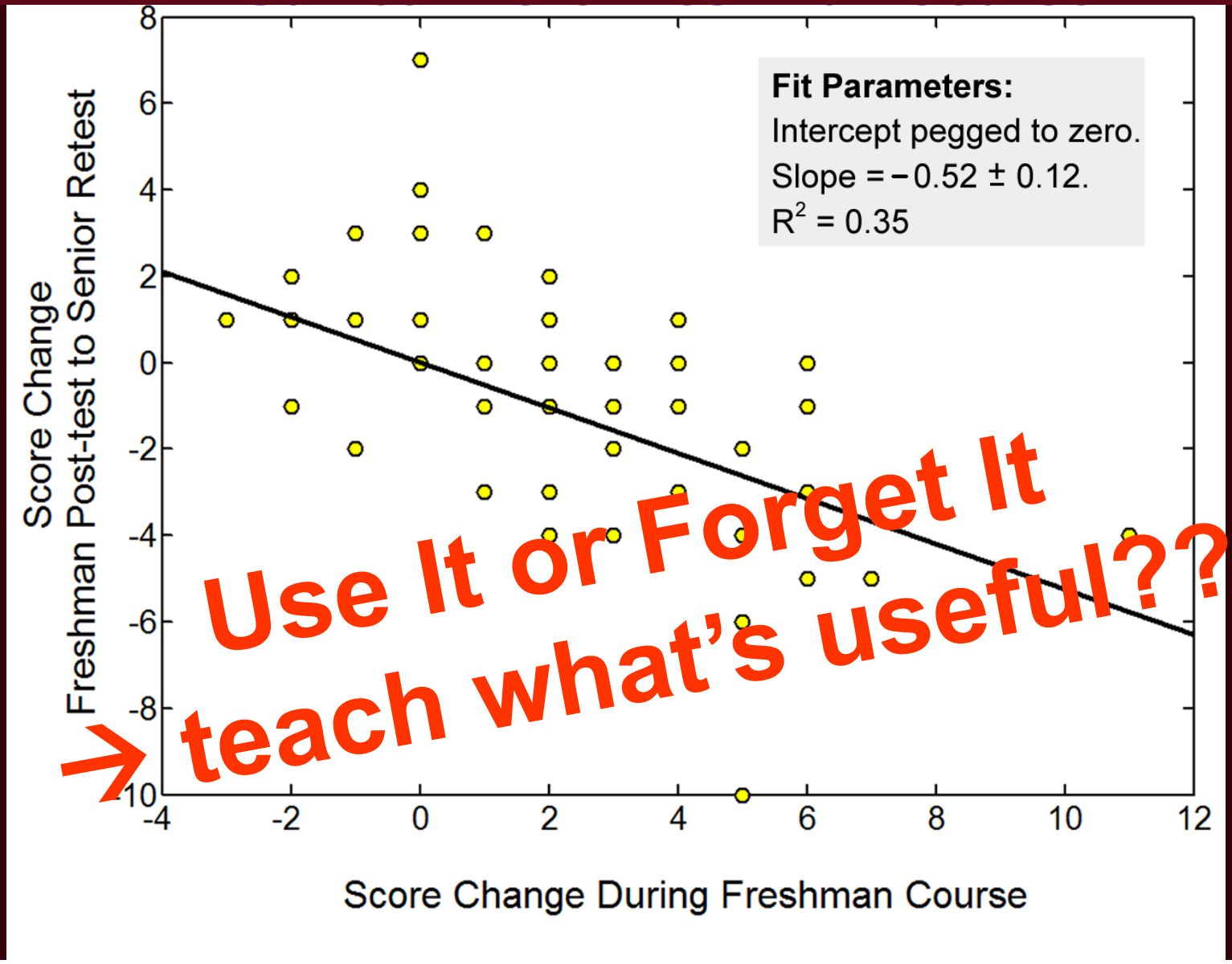

RETENTION from Pre- & PostTest
100%
Forbidden Region:
More than 100% on posttest!
Pure gain curve – intercept at 100%
Score Shift from Pre to Post →
0
100%
Pretest Score →
Pure loss curve – intercept at 0%
Forbidden Region:
Less than 0 on posttest!
–100%

Increased Gain on Subtest Math



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

Subtest Physics Concepts: 50% **Loss** of ***Knowledge Gained*** in Freshman Course



Use It or Forget It

teach what's useful??

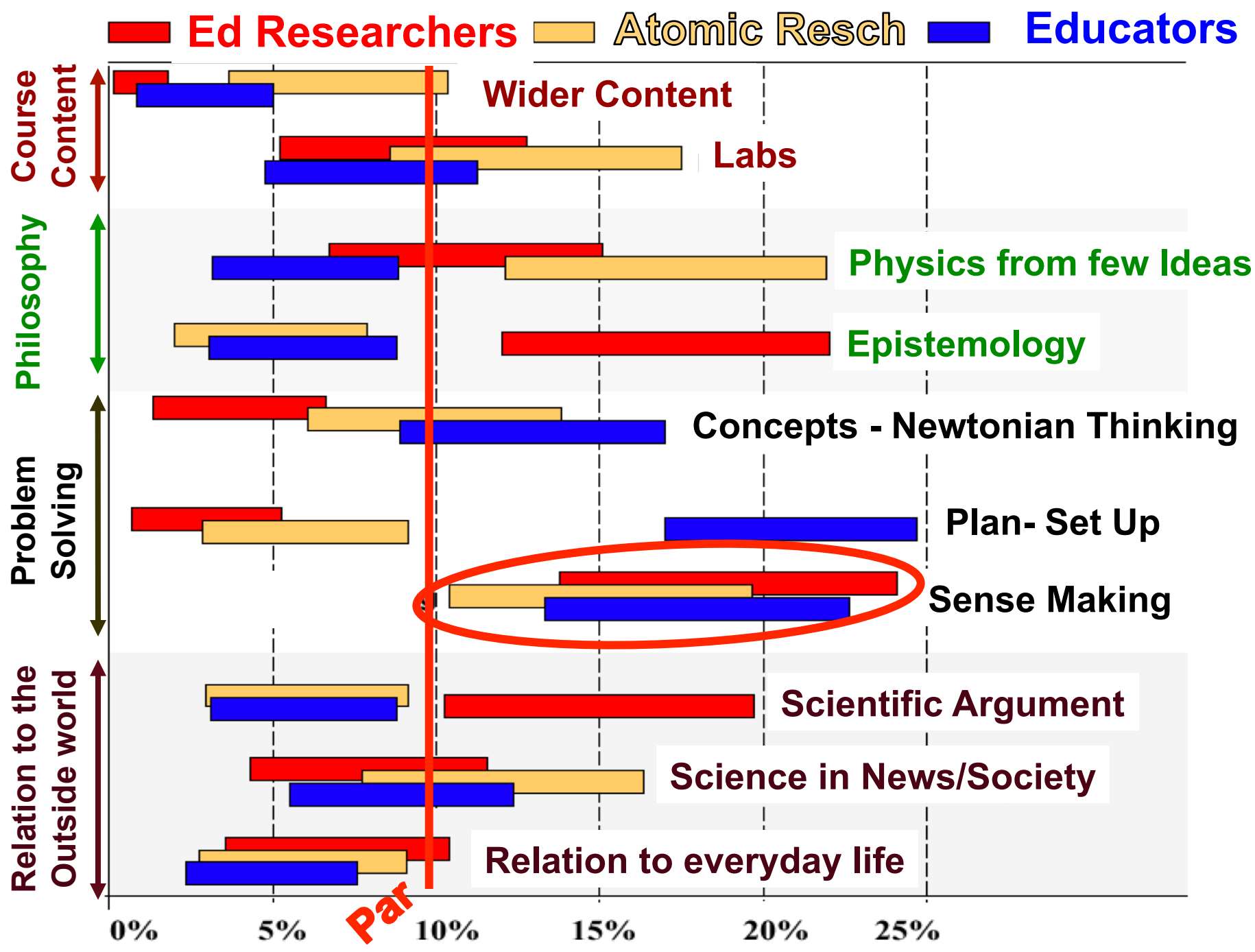
What To Teach in Introductory Physics

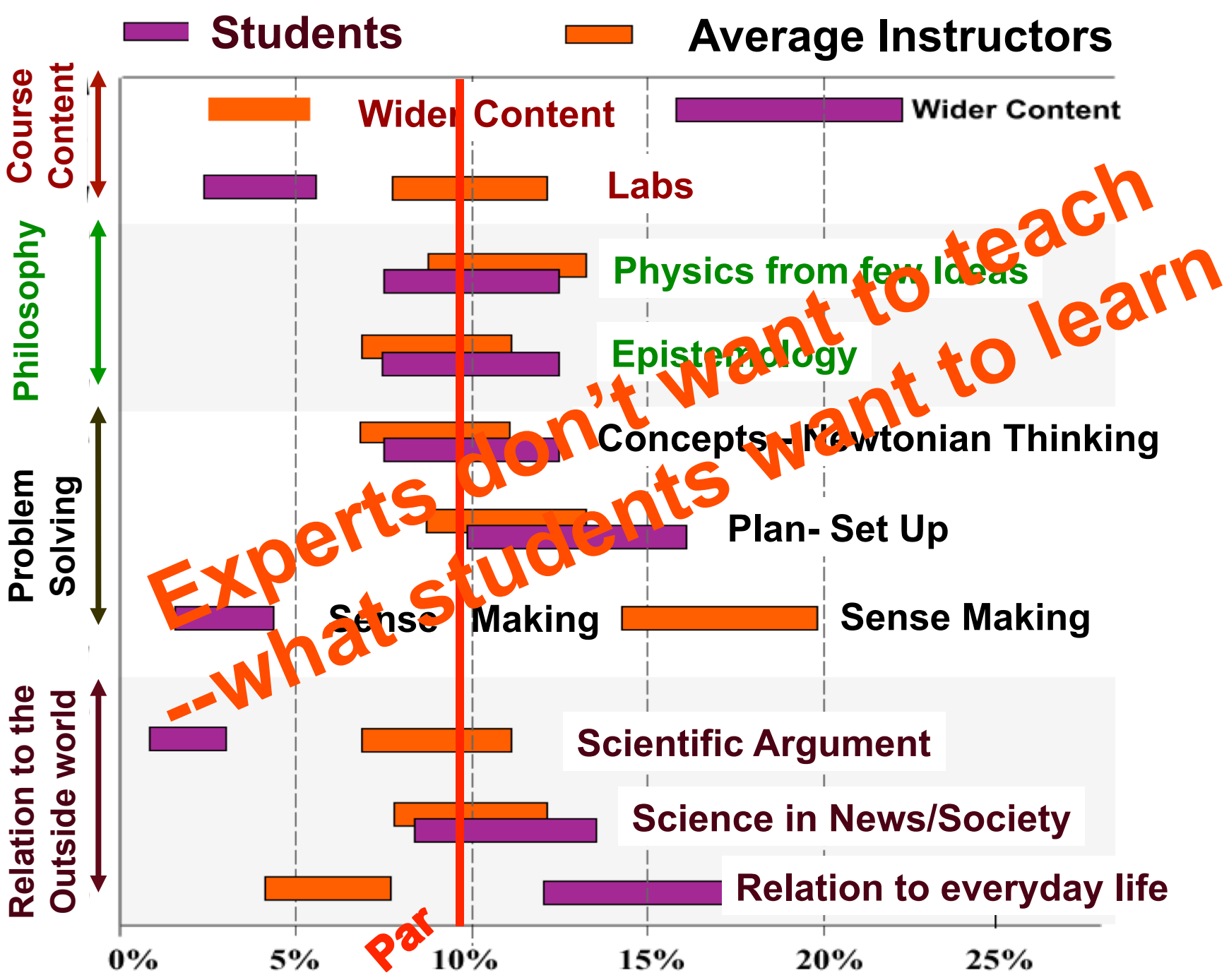
David E. Pritchard, Analia Barrantes, Brian Belland

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?


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


Students
Average Instructors
Course Content
Philosophy
Problem Solving
Relation to the Outside world
Wider Content
Wider Content
Labs
Physics from few Ideas
Epistemology
Concepts - Newtonian Thinking
Plan- Set Up
Sense Making
Sense Making
Scientific Argument
Science in News/Society
Relation to everyday life
Par
0%
5%
10%
15%
20%
25%
Experts don't want to teach
--what students want to learn

Rethinking Education in the Age of Technology
-A. Collins and R. Halverson

	School World Now	Digital World/Life
Goal	Just in Case Knowledge	Just in Time Knowledge
When	To Age 21, Sep-June 8AM-3PM	Lifelong Learner, Anytime, anywhere
Group By	Age	Interest, Level, Profession
Method	On paper	Online
Teacher Role	Subject Expert, Source of Information	**Coach & Guide**

The contemporary school is inappropriate!

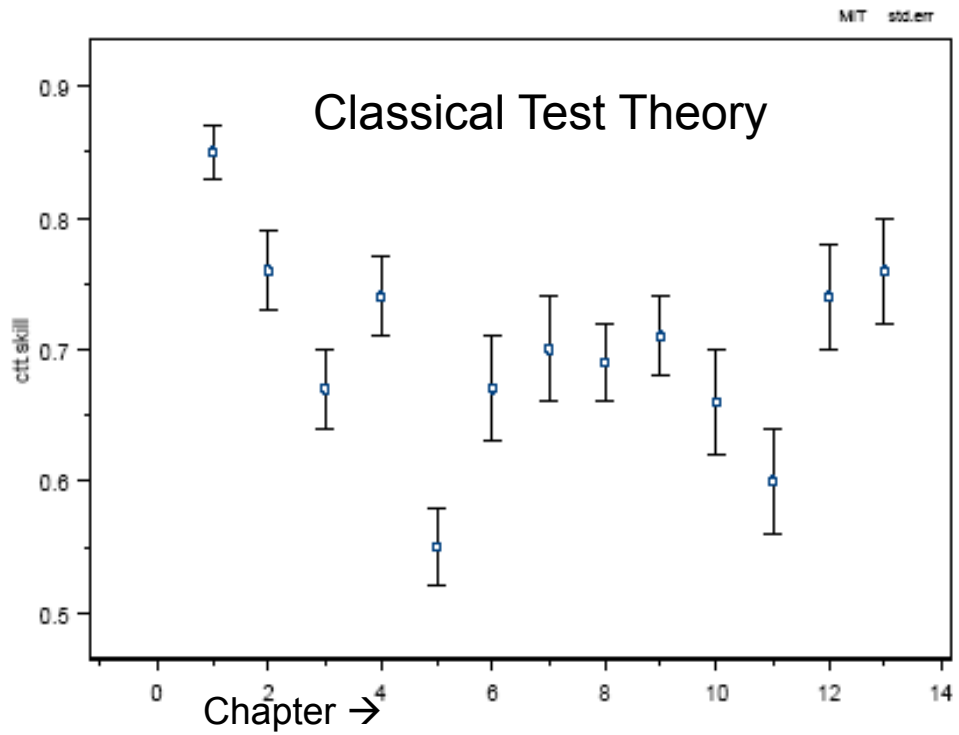
Rethink: Role of Teacher, Centrality of Online

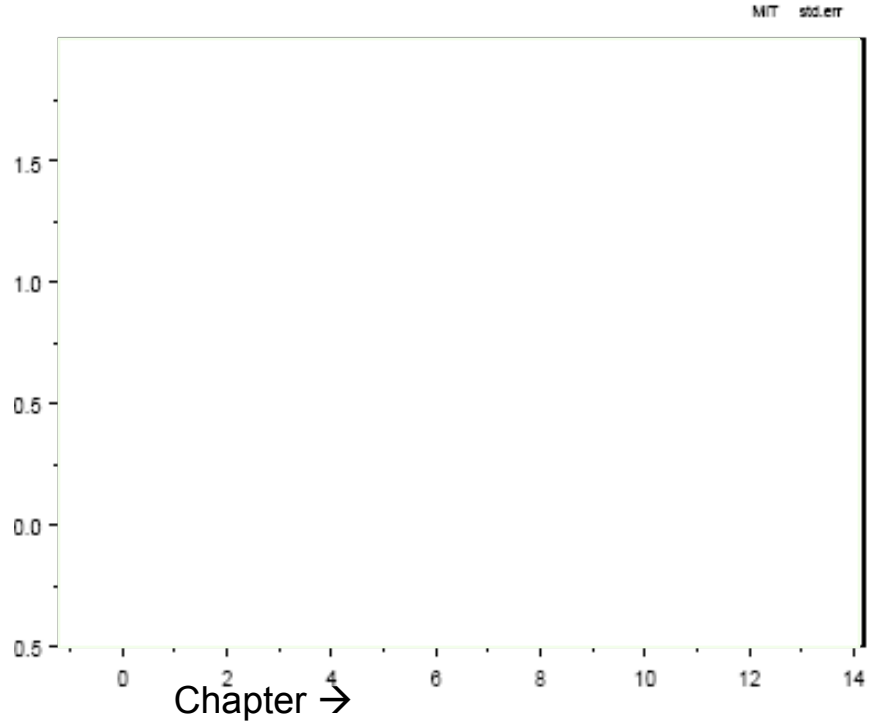
My Zero Based Thinking

- Make Online Education Interactive & **Integrated**
  - Personal Tutors, Games, Class, Social Software
- Universal Assessment of Every Key-Stroke
  - To guide student & tutor toward their goals
  - To certify the student's progress
- Improve Content Interactively/w Data Mining
  - Have students suggest/rank utility of resources
  - Solicit student feedback, measure effect, for content
  - Example with Video
- Help Students Educate Each other
  - Discussion Groups with Ranked Peers
  - Student groups produce content, system judges it

Detailed Homework Skills vs. Topic

Classical Test | Item Response



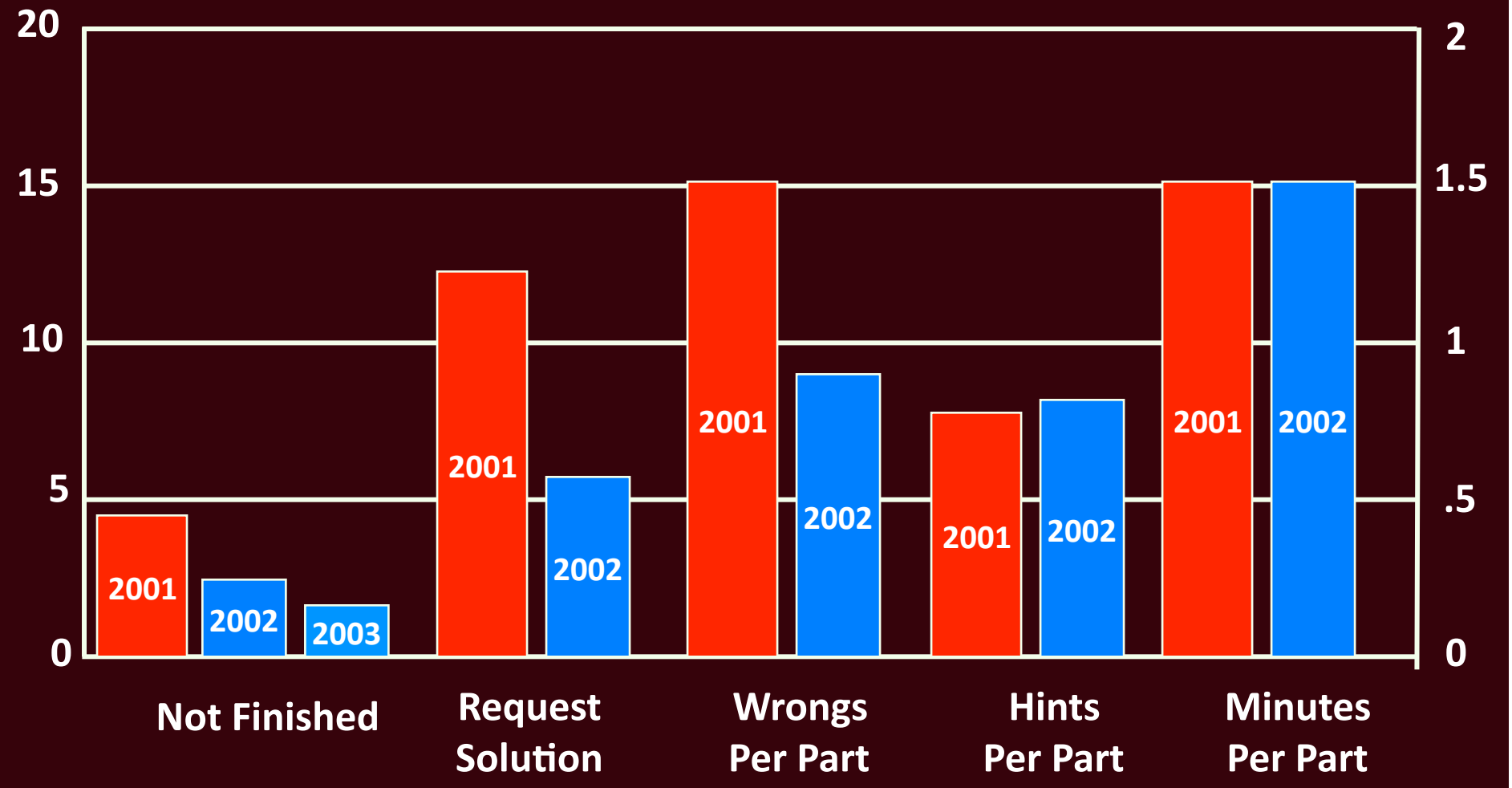


The IRT graph has less error and shows the trend better: Students selected by SAT scores have an advantage until the fifth week of the course at MIT (vs. second semester in most colleges as claimed by ETS).

Zero Based Thinking

- Make Online Education Interactive & **Integrated**
  - Personal Tutors, Games, Class, Social Software
- Universal Assessment of Every Key-Stroke
  - To guide student & tutor toward their goals
  - To certify the student's progress
- Improve Content Interactively/w Data Mining
  - Have students suggest/rank utility of resources
  - Solicit student feedback, measure effect, for content
  - Example with Video
- Help Students Educate Each other
  - Discussion Groups with Ranked Peers
  - Student groups produce content, system judges it

Content Revision from Feedback Reduces Percentages of Students Not Finishing and Requesting Solution, and Reduces Number of Wrong Answers



TITLE of Video

Search

Streaming text of lecture with audio. This is a transcription of the lecture that allows indexing, search, etc. A keyword search starts the system in the appropriate place.

Student can highlight any part of window and Add To My Notes

Course ROADMAP

This might be the Table of Contents with highlight of where this Video fits in.

VIDEO Window

The video should be a combination of equations, power-points, demonstrations and professor. Videos should be a maximum of 10 minute segments, ideally with integrated peer instruction (clicker) questions.

Contains standard start and stop buttons.

User-Ranked FAQ's relevant to lecture,

FAQ's are rearranged with the most popular at the top of the list. Prof. of TA gives some video responses

Suggest URL's that helped you!

Find more via Data Mining or Targeted Google Window

Zero Based Thinking

- Make Online Education Interactive & **Integrated**
  - Personal Tutors, Games, Class, Social Software
- Universal Assessment of Every Key-Stroke
  - To guide student & tutor toward their goals
  - To certify the student's progress
- Improve Content Interactively/w Data Mining
  - Have students suggest/rank utility of resources
  - Solicit student feedback, measure effect, for content
  - Example with Video
- Help Students Educate Each other
  - Discussion Groups with Ranked Peers
  - Student groups produce content, system judges it

How and What Are Students Learning, and Why?

To Improve Education Scientifically

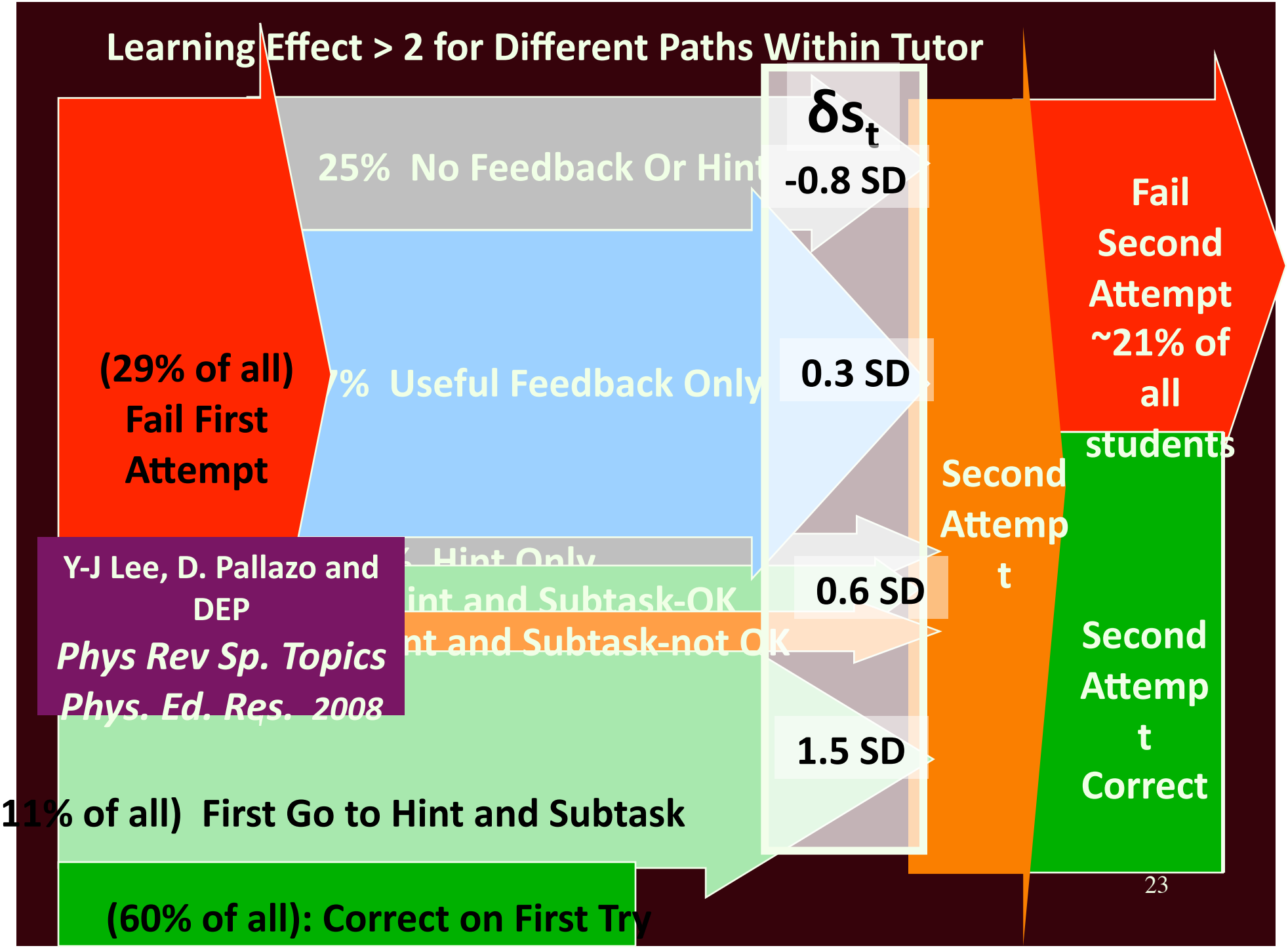
We must know:

- What Students Learn
- How they learned it
- How long it took them

Then we can optimize their learning

Online Learning Systems Give Enough Data

But NO GOOD if we don't teach right stuff


Learning Effect > 2 for Different Paths Within Tutor
δs_t
25% No Feedback Or Hint
-0.8 SD
(29% of all) Fail First Attempt
7% Useful Feedback Only
0.3 SD
Fail Second Attempt ~21% of all students
Second Attempt
Hint Only
int and Subtask-OK
nt and Subtask-not OK
0.6 SD
Y-J Lee, D. Pallazo and DEP
Phys Rev Sp. Topics Phys. Ed. Res. 2008
Second Attempt Correct
1.5 SD
(11% of all) First Go to Hint and Subtask
(60% of all): Correct on First Try

How and What are Students Learning

And Why?

http;//RELATE.MIT.edu

Dave Pritchard

Andrew Pawl

Analia Barrantes

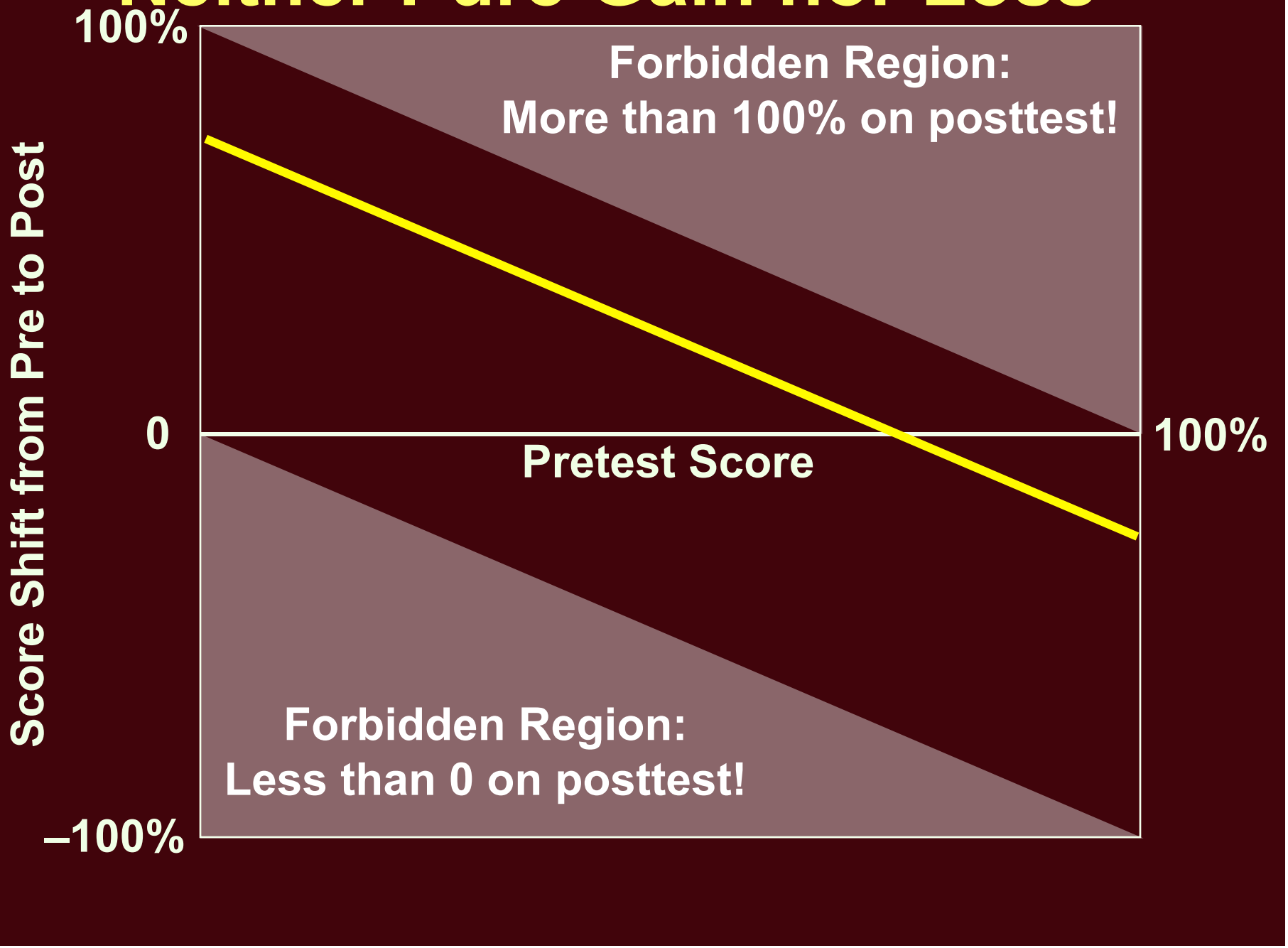
Saif Rayyan

Raluca Teodorescu

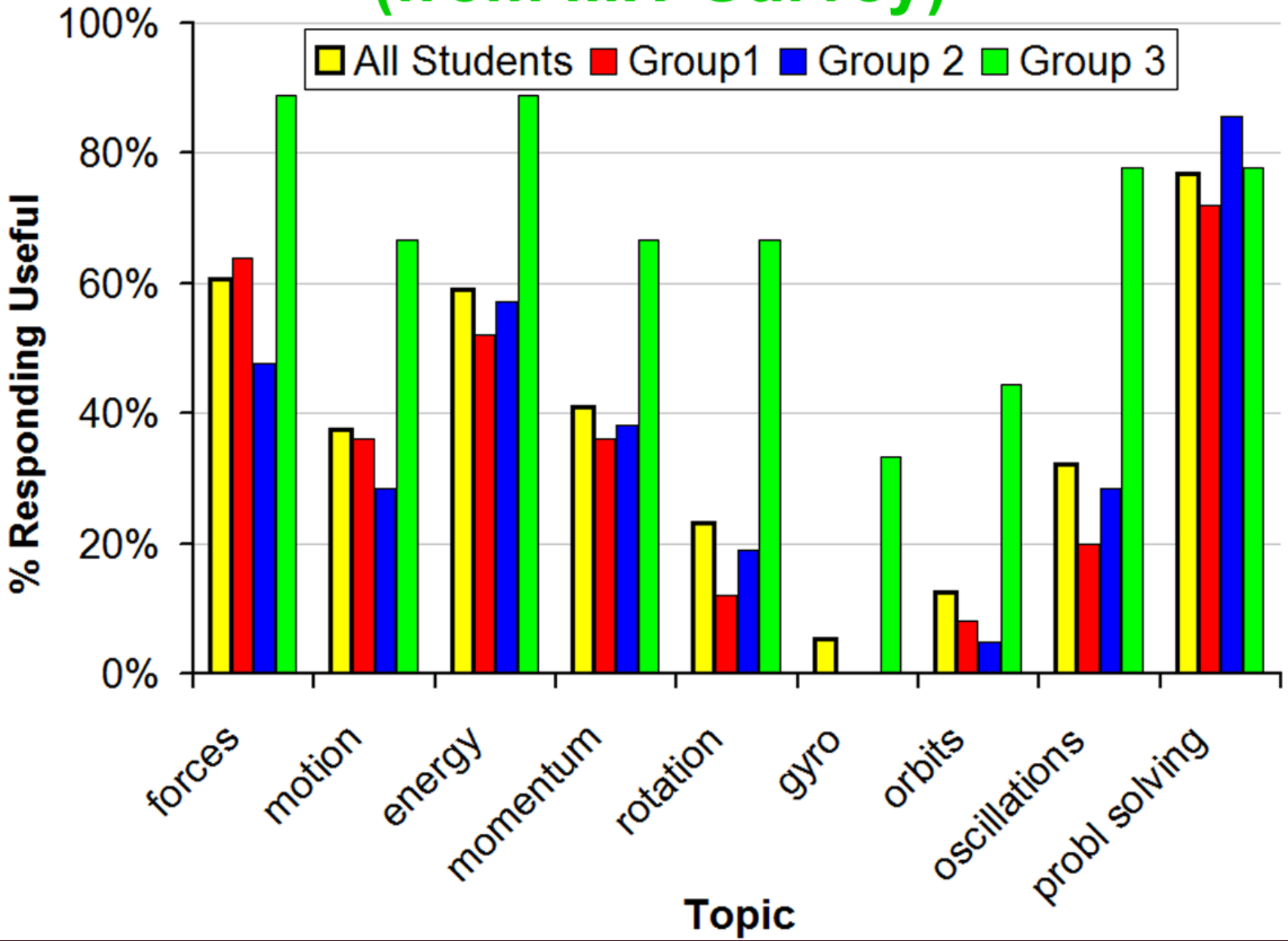
Saif Dave Raluca Andy

Analia

Neither Pure Gain nor Loss



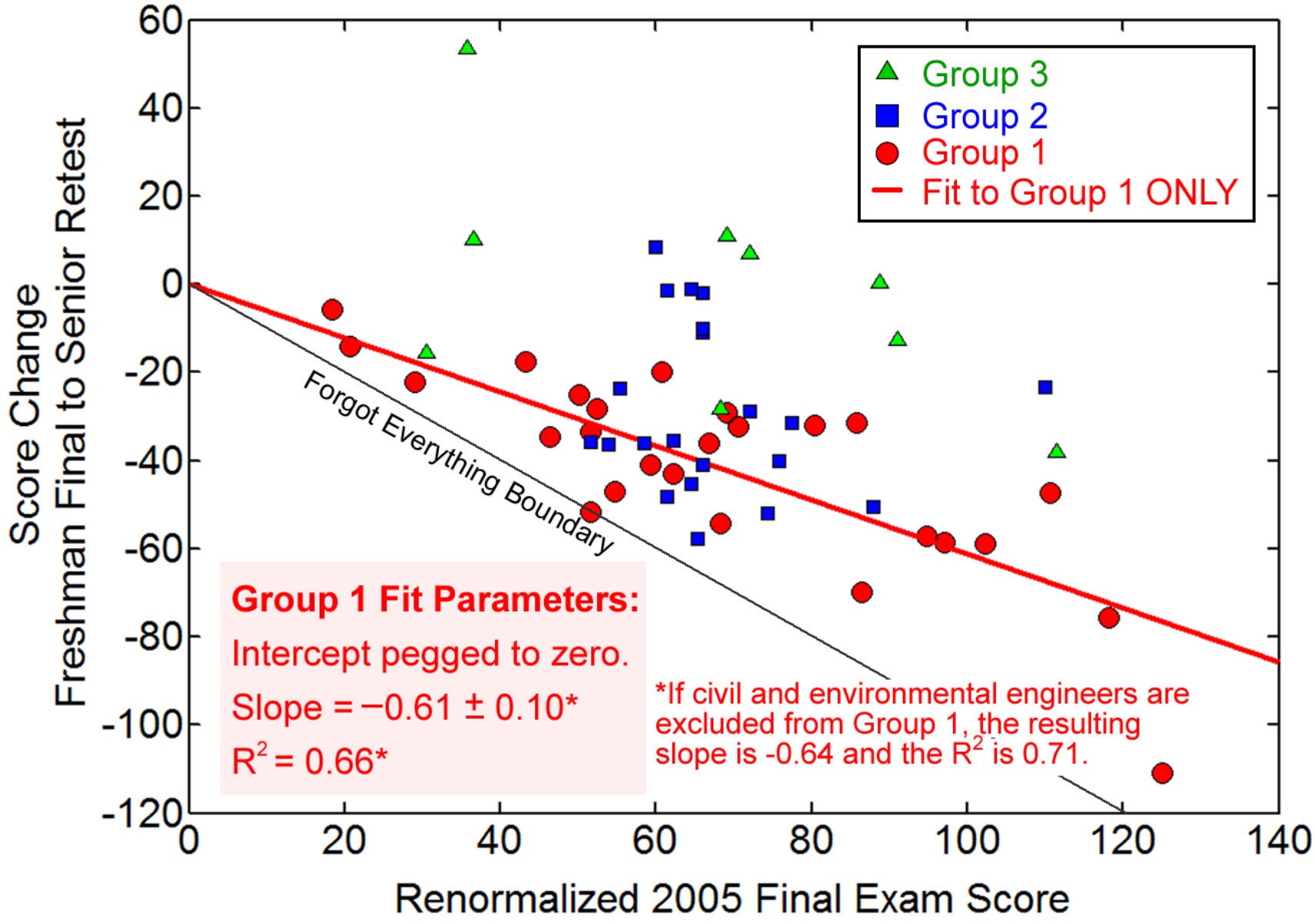
Perceived Utility of Topics by Group (from MIT Survey)



12 Distilled Questions, 4 Categories

Course Content	More Content: Gyroscopes, QM, Nuclear
	Discovery-based or Traditional lab
Scientific Ideas	Scientific Method
	Physics from a few ideas
	Epistemology, how do I know, derivations
Problem Solving	Vocabulary of Subject Domain
	Concepts - should be Newtonian Thinkers
	Problem Solving - concepts, plan, set up
	Sense - making of solution, estimation
Physics & World	Communication of Solution/Science
	Understanding of Science in News
	Relation to everyday life/things

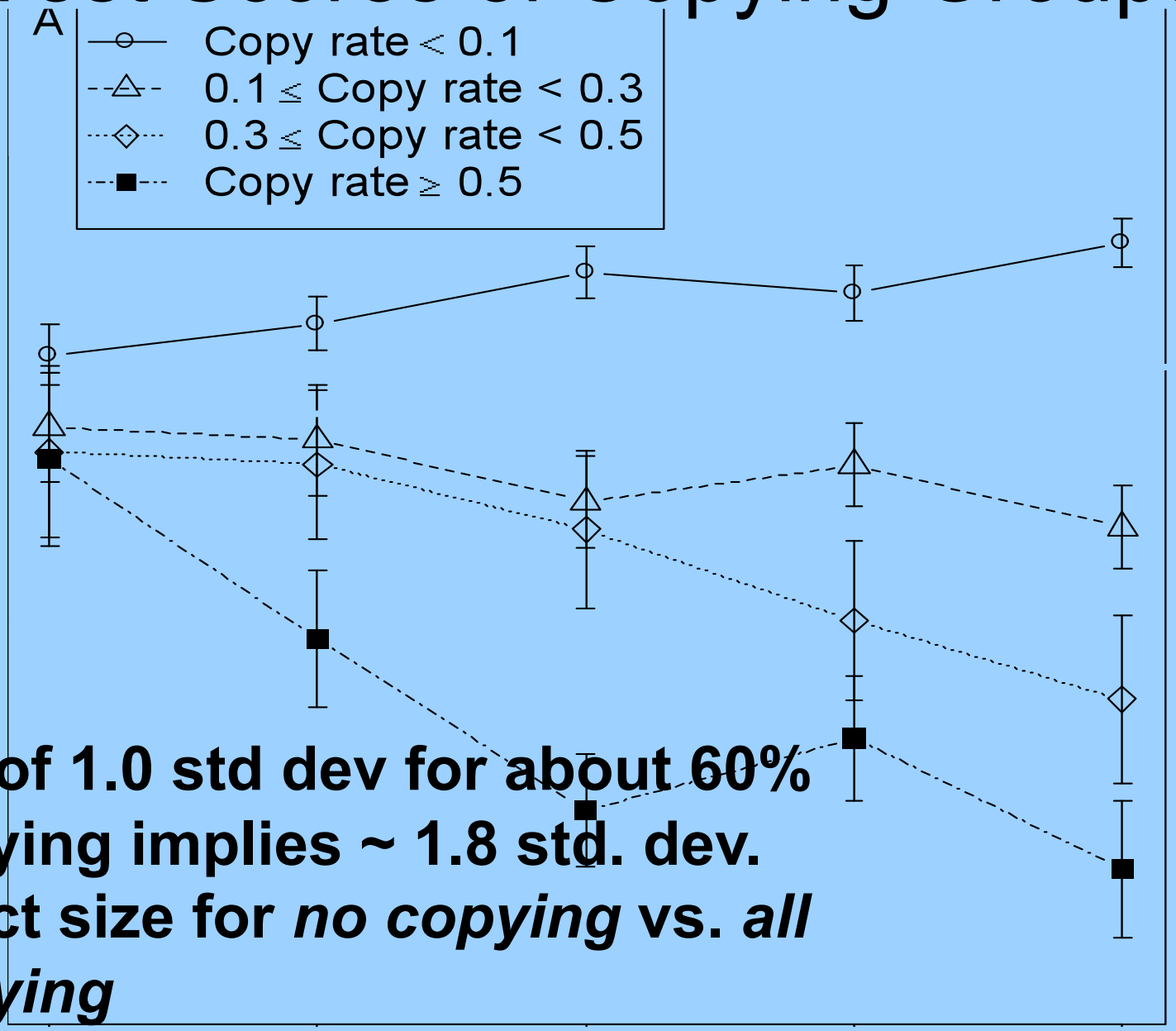
60% Lost on Analytic Final Exam Problems Among Group 1 Students



Surprise: All Groups IMPROVED on "standard" mathematical material

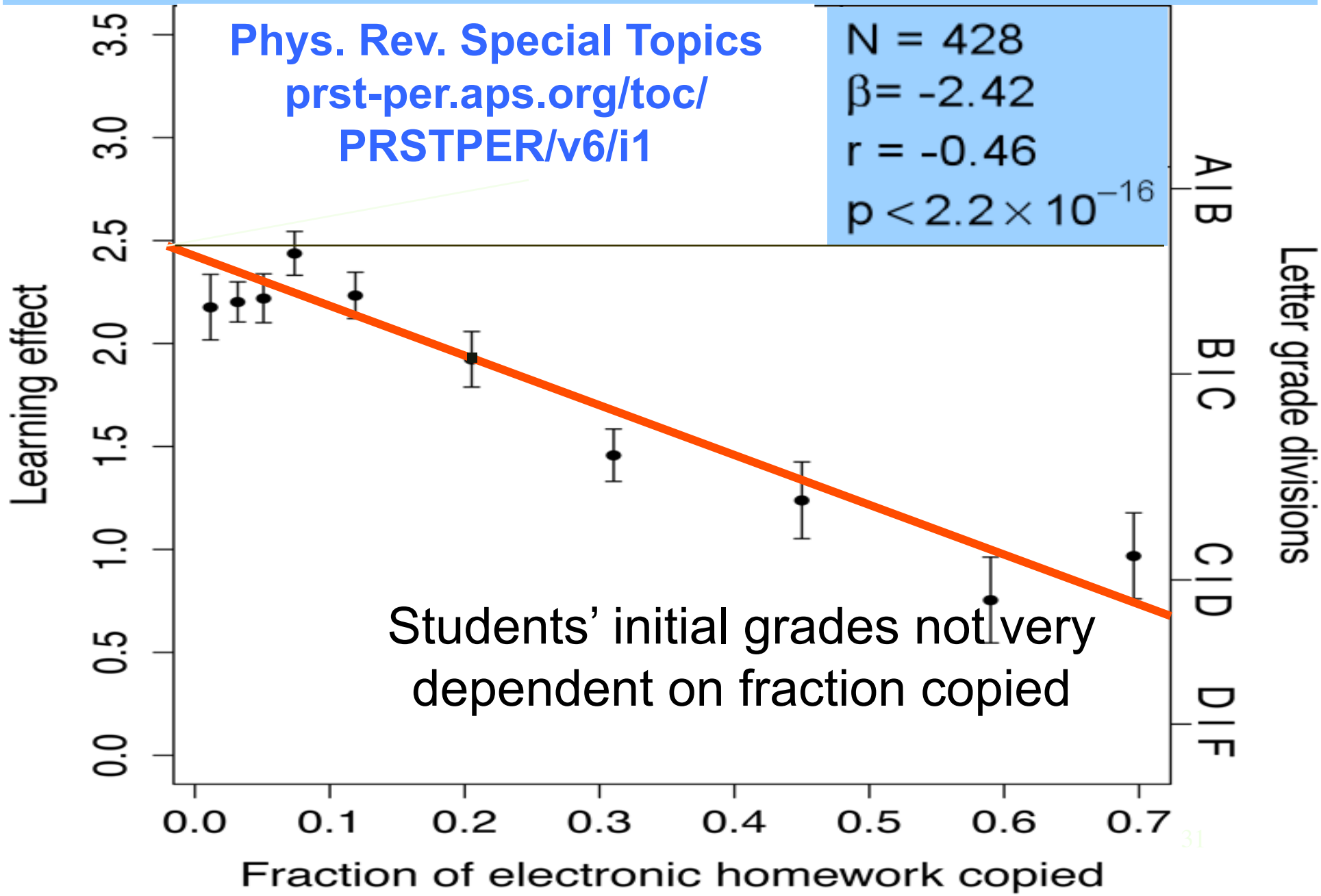
Subtest S of the MBT	
Included Questions	**Topic**
1, 2, 3, 23, 24, 25	Graphical Kinematics
13, 14	1-D Equilibrium
19	2-D Vector Addition

Test Scores of Copying Groups



Net of 1.0 std dev for about 60% copying implies ~ 1.8 std. dev. effect size for *no copying* vs. *all copying*

Analytic Final Exam vs. Copying



Teach→Learn: Assess Learning

What: Are Students Learning?

Requires TWO ASSESSMENTS:

How: Which activities cause learning?

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

- Much Harder to Determine

What: Habits are Bad or Good?

Must Stop Bad, and Encourage Good

Why: Are We Teaching the Right Stuff?

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

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

- Just a correlation: causation by inference

MIT Remedial Course

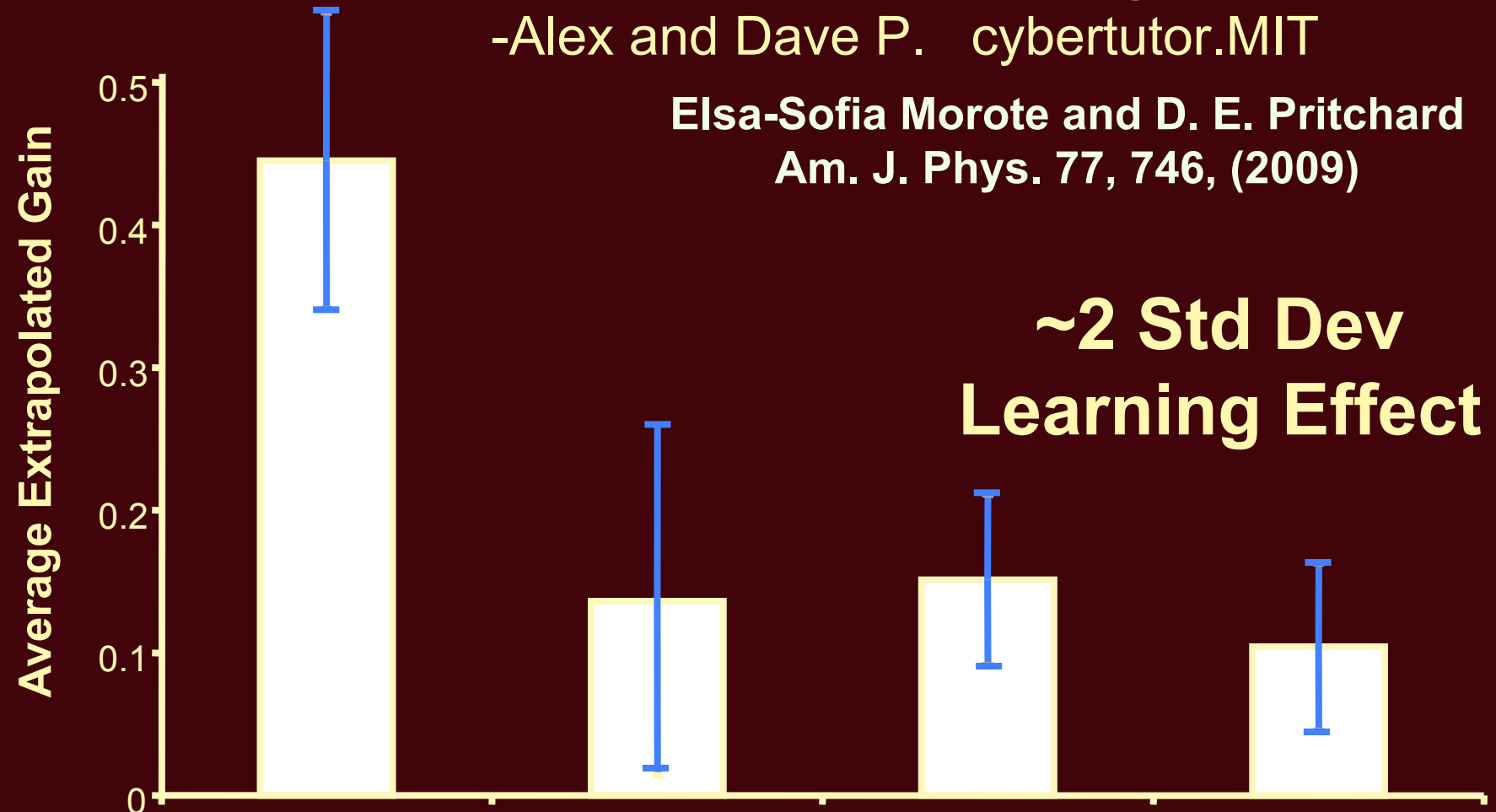
Gain on Final Exam

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

-Alex and Dave P. cybertutor.MIT

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

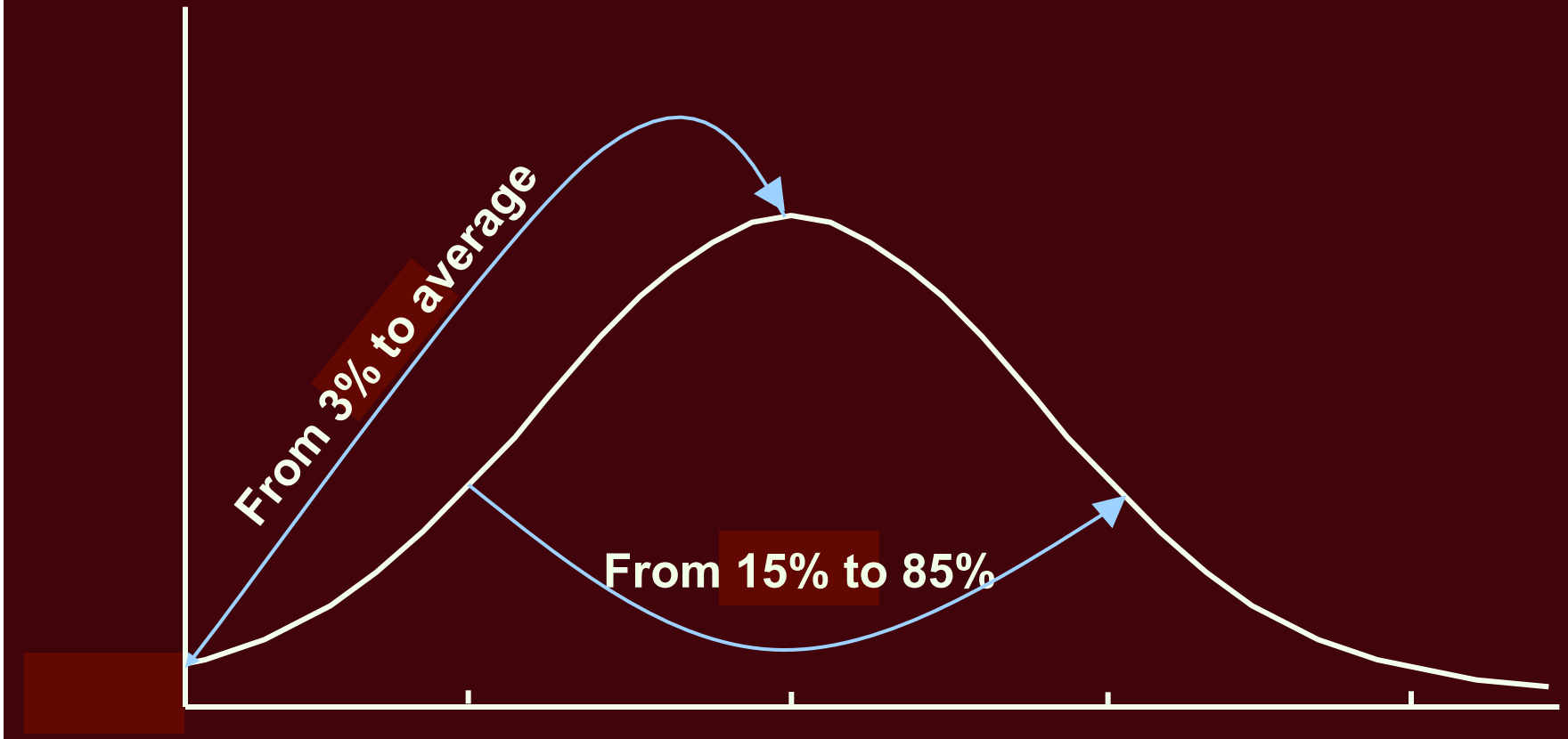
~2 Std Dev Learning Effect



	Mastering Physics	Written Homework	Group Problems	Class Participation
p-values	0.00002	0.26	0.013*	0.076

Two Sigma Effect Size

- About what expert personal tutor gives
- Two grade levels in elementary school



Encouraging: Students Learn What we Tutor!

Orientation

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

- Now: Online Socratic Tutor used for Data Mining

- Next: HABITS
  - Copying (bad)
  - Requesting help before guessing (good)

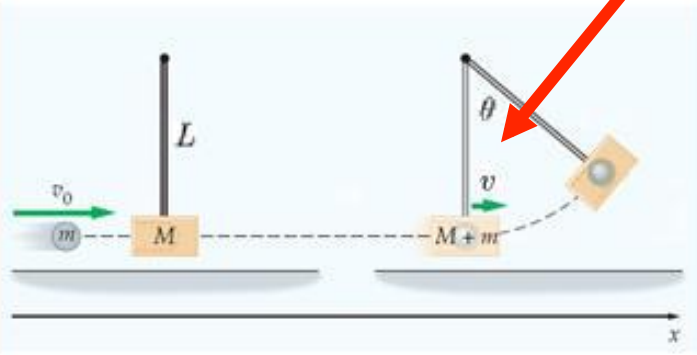
Socratic Pedagogy of Online Tutor

Demand Appropriate Response

Ballistic Pendulum

In a *ballistic pendulum* an object of mass m is fired with an initial speed v_0 at the bob of a pendulum. The bob has a mass M (usually $M \gg m$), which is suspended by a rod of length L and negligible mass. After the collision, the pendulum and object stick together and swing to a maximum angular displacement θ as shown .

Intro 1



claire masson

Part A

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

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

v_0 =

reset help

submit hints my answers show answer review part

submit problem

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

Hint 2. Detemine which physical laws and principles apply Open

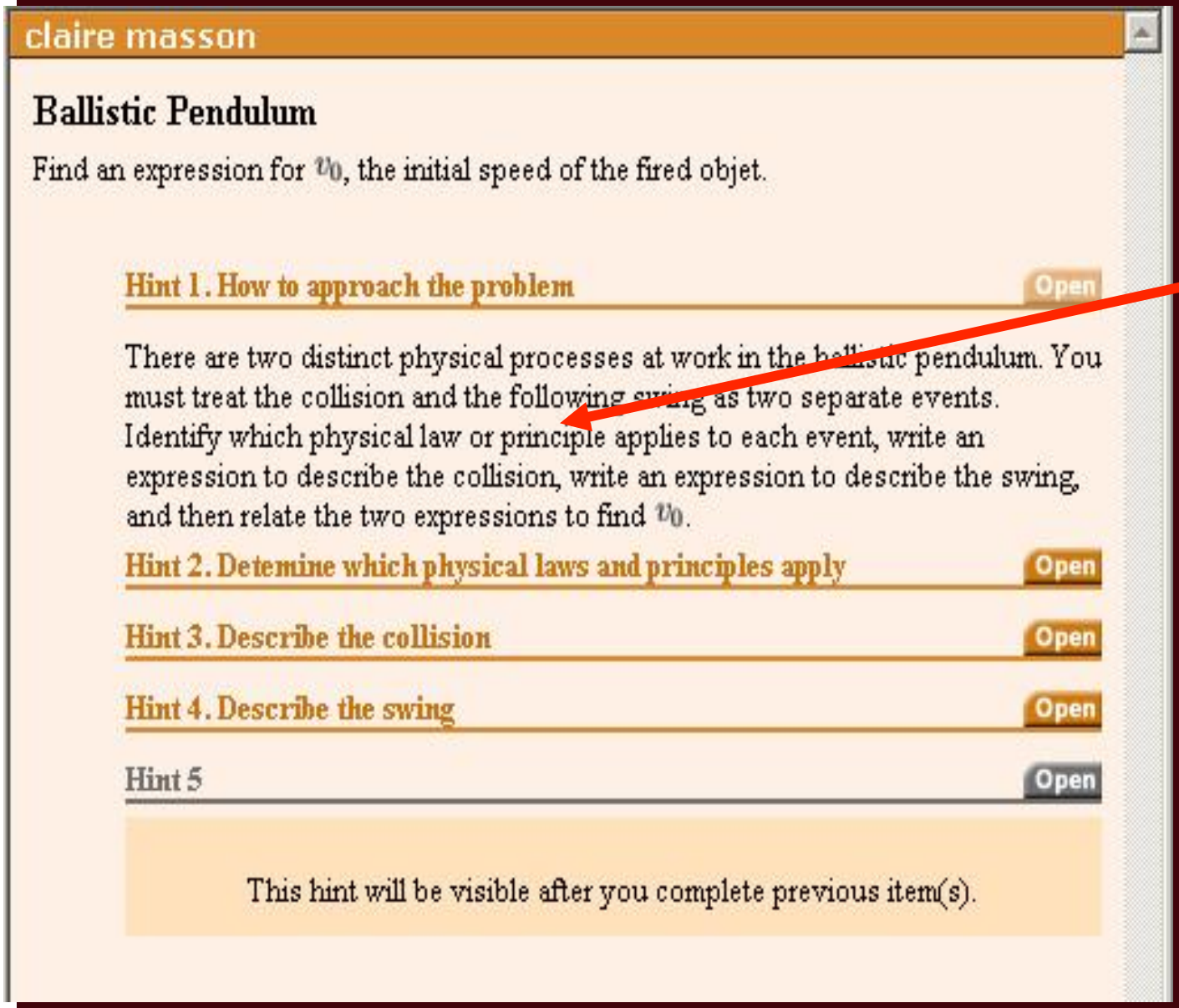
Hint 3. Describe the collision Open

Hint 4. Describe the swing Open

Problem Statement & Figures

Requestable List of Hints (plan of attack)

Declarative Hint



Hints open on request in any order.

This is a Declarative Hint.

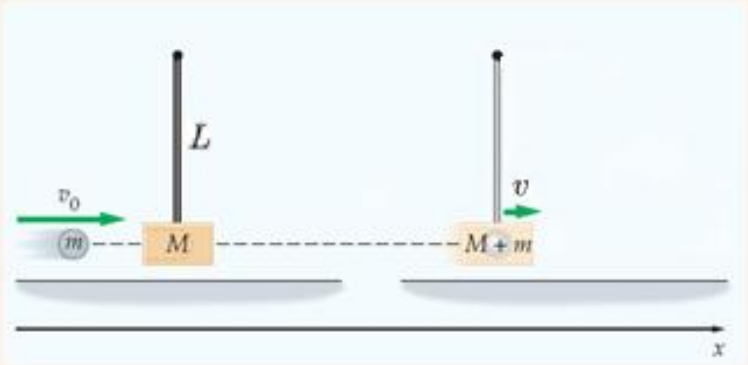
It Informs, Suggests, Reminds, etc.

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

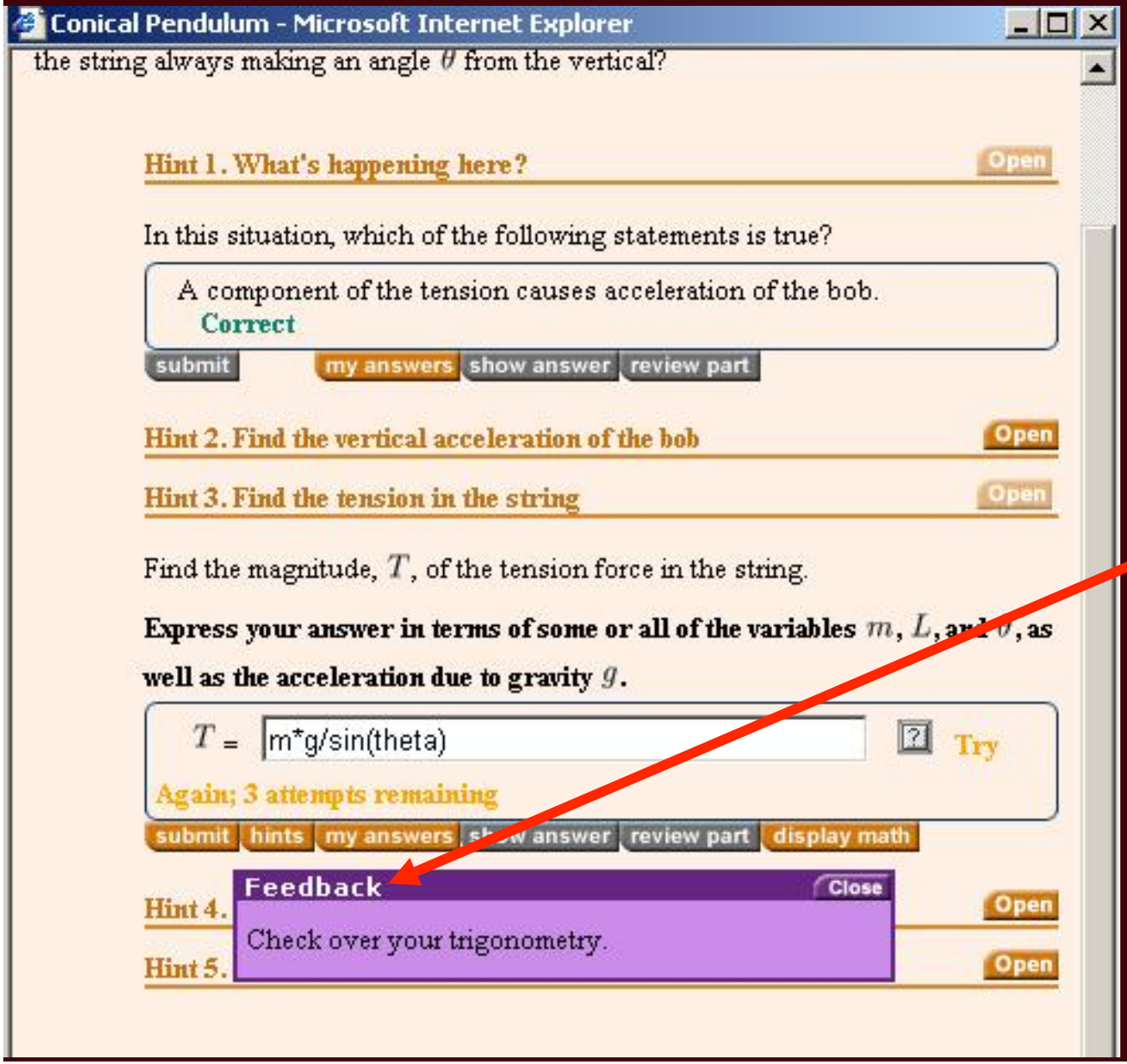
Hint 5 Open

This hint is a SubTask

It Requests a Response that helps answer the main question.

Responding is optional, although informative.

Wrong Answer Feedback



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

Eductional Data Mining: Tutors >>Tests

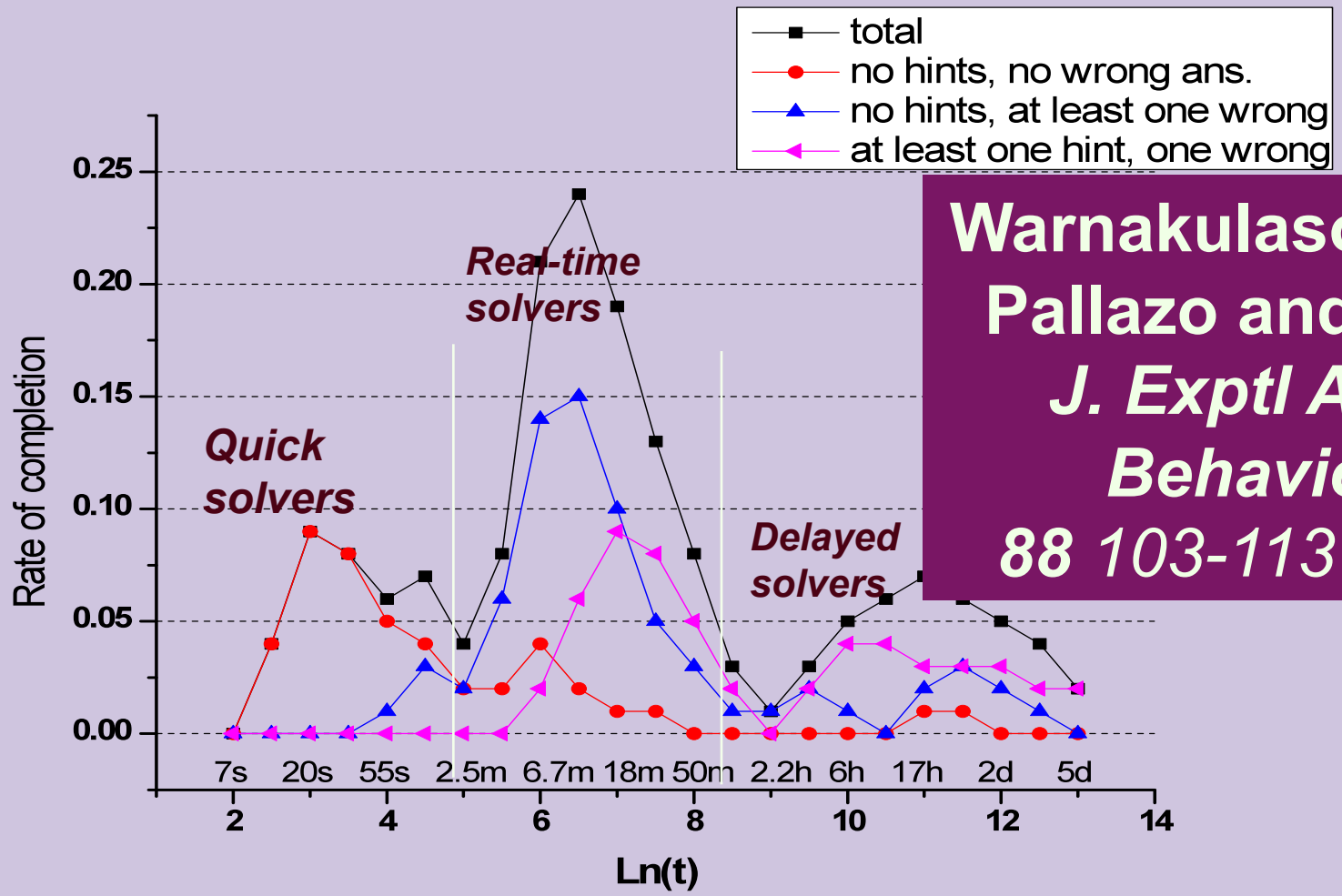
Fine Grain Assessment – Holy Grail

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

Habits of Mind and Behavior

- What Habits help/hinder learning??
- Shih: working through all hints gives learning
- Palazzo/me: homework copying reduces learning
- Better to open hints prior to responding?

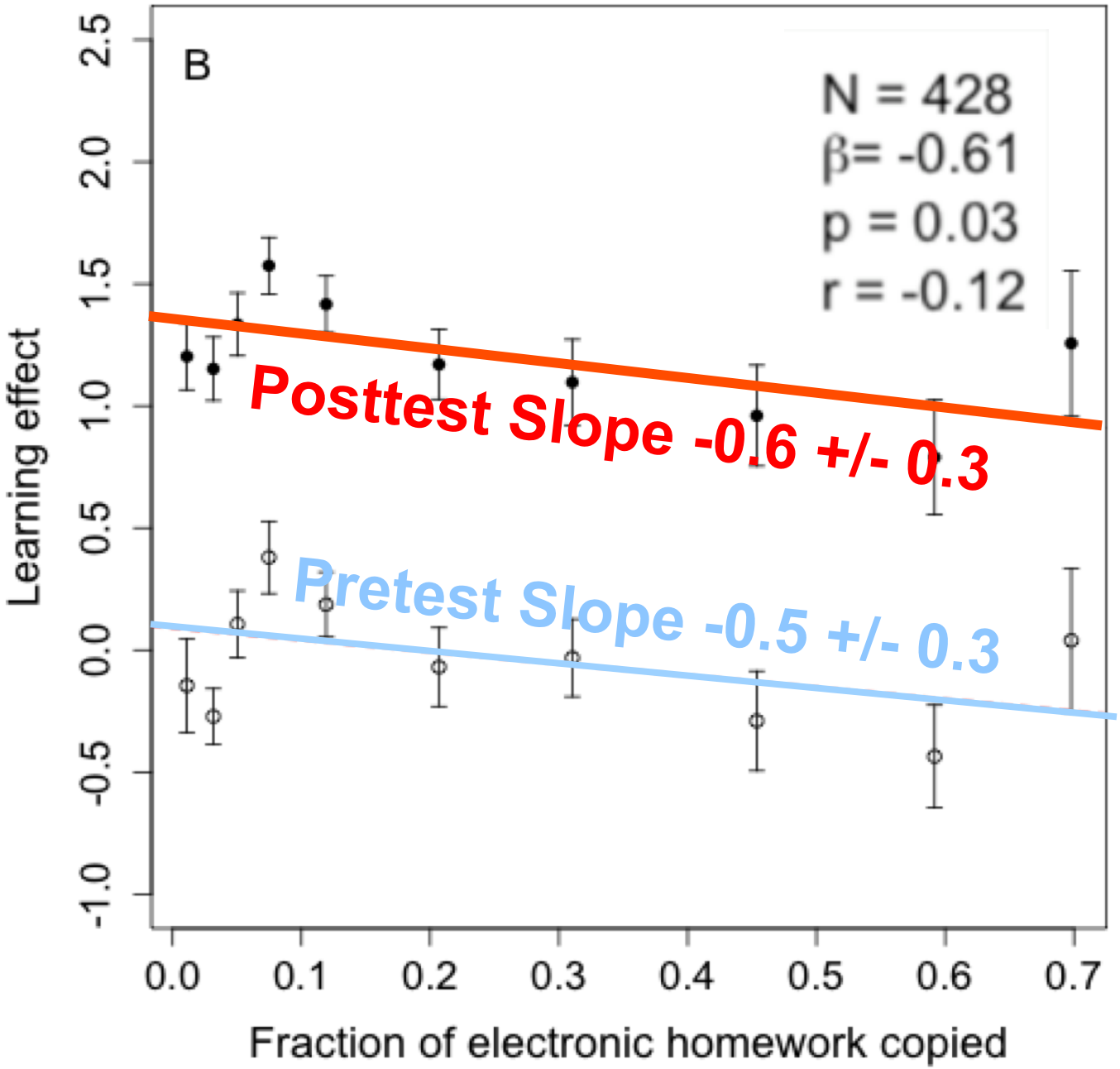
Detect Copying ← Quick, Correct Answer



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

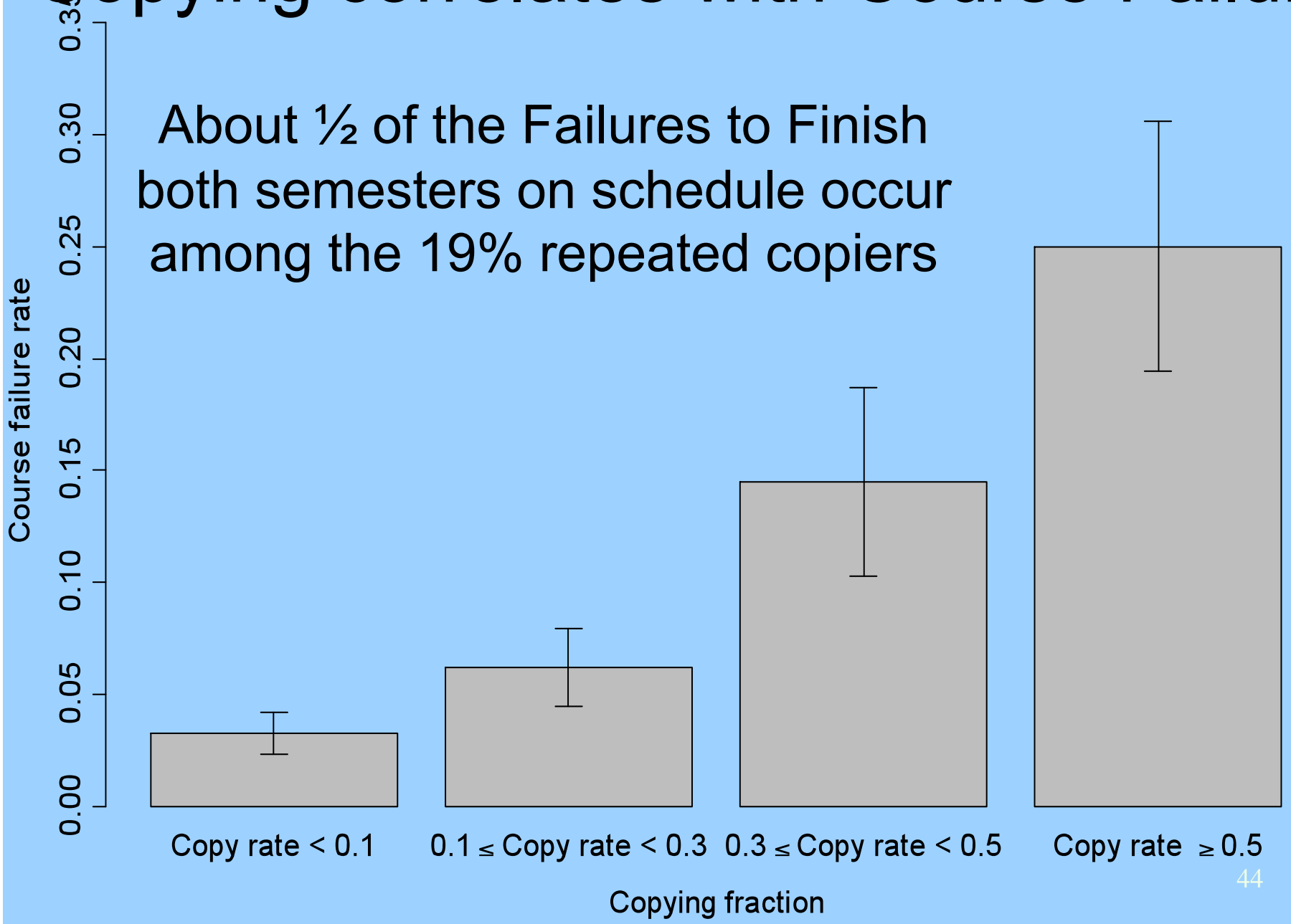
Dependence of Concept on Copying



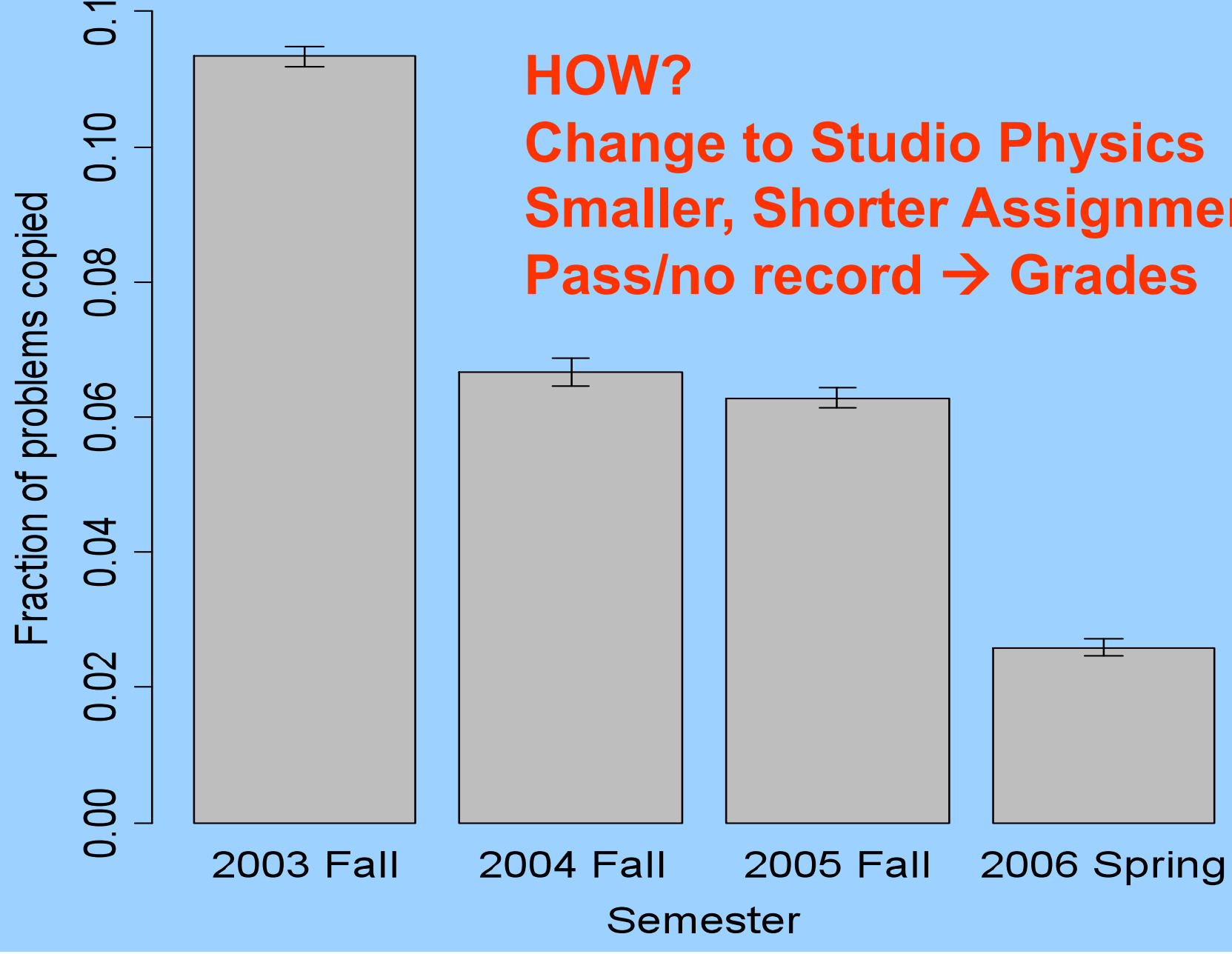
Copying has insignificant correlation with Gain on ConceptTest Copiers and Non-copiers both have learning effect ~ 1.2

Copying correlates with Course Failure

About ½ of the Failures to Finish both semesters on schedule occur among the 19% repeated copiers



Copying at MIT Has Been Reduced!



HOW?
Change to Studio Physics
Smaller, Shorter Assignments
Pass/no record → Grades

Homework Copying
--a Serious Academic Concern

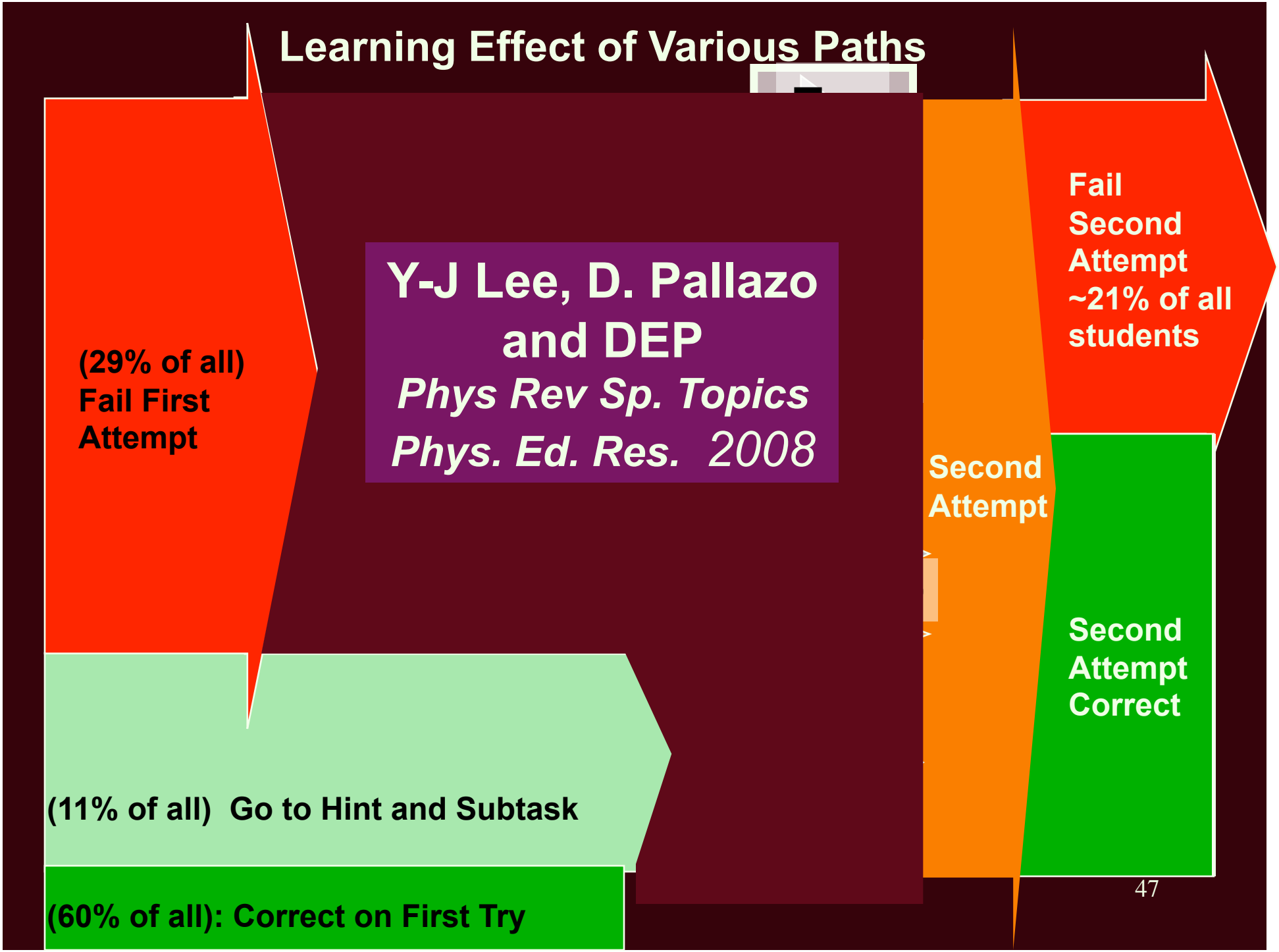
Homework Copying → Dramatic Academic Decline

The Decline is Specific to Type of HomeWork Copied

Demographic and Personal Factors Important

Course Format Changes Reduced Copying X 4

Copying homework is serious learning problem that you can do something about!


Learning Effect of Various Paths
(29% of all) Fail First Attempt
Y-J Lee, D. Pallazo and DEP
Phys Rev Sp. Topics Phys. Ed. Res. 2008
Second Attempt
Fail Second Attempt ~21% of all students
Second Attempt Correct
(11% of all) Go to Hint and Subtask
(60% of all): Correct on First Try

Why is Hints-First so Beneficial?

- Metacognitive Monitoring of Own Knowledge?
  - Know they don't know
  - Then know when they do
- Observation: Not same students each time
- We'll have to do more research!

Orientation

- 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
- WHY should we teach what we teach?

What Do Graduating Seniors Recall?

Do they remember our wisdom??

Expect users of mechanics (Gp 3) will recall more than humanities (Gp 1)

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

Professors & Students?

- 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.

Digital Education Future?!

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