Experiencing and Unpacking the Active Learning Classroom

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Overview: In this session participants will experience several different active learning strategies and implementation techniques designed to improve students learning and make the classroom more intellectually engaging, inclusive and equitable.

Learning Outcomes:

Participants will be able to:

- Identify a wide range of active learning activities
- Describe different implementation techniques and strategies.
- Discuss how active learning activities can be sequenced together to provide an intellectually engaging classroom that promotes students' learning

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Center for Astronomy Education ▸▸ *Dedicated to improving teaching and learning in Astronomy 101*

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About CAE

The Center for Astronomy Education (CAE), directed by Ed Prather and Gina Brissenden (Univ. of Arizona), is devoted to improving teaching and learning in general education, college-level Earth, Astronomy and Space Science (Astro 101) by conducting fundamental research on student beliefs and reasoning difficulties related to astronomy, and instructor implementation difficulties related to teaching astronomy. We use the results of our research to inform the development of research-validated curriculum and assessment materials for use in the Astro 101 classroom. These research-validated curricula & assessment materials frame our professional development CAE Teaching Excellence Workshops for Earth, Astronomy and Space Science instructors. The goal of these professional development workshops is to increase the pedagogical content knowledge of Earth, Astronomy and Space Science instructors and improve implementation of these curricula and assessment materials.

A composite image of stellar cluster NGC 1333. Image Credit: NASA/JPL-Caltech

We Do Workshops

CAE provides many teaching-related professional develop workshops throughout the year and across the country.
Learn more

We Have Stuff for Your Classroom

CAE has a wide variety of instructional and assessment materials ideal for college-level astronomy.
Learn more

Connect with the Greater Astronomy Community

Come join the discussion and connect with other instructors in our Yahoo group Astrolrner@CAE.
Learn more

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About | Workshops | **Materials** | Community | Join Our Mailing List!

Materials | Publications

Instructional and Workshop Materials

Classroom Instructional Materials

Images from Lecture-Tutorials for Introductory Astronomy, Third Edition
Here you will find individual .jpg versions of all the artwork in Lecture-Tutorials for Introductory Astronomy, Third Edition. You will also find Power Point slides of each image grouped by sections in the book.

- Images from Lecture-Tutorials for Introductory Astronomy, Third Edition (Zip, 41.69 MB)

Voting Card

- A-B-C-D Voting Card (PDF, 115 KB)

Detecting Exoplanets Curriculum

- Lecture-Tutorial: Detecting Exoplanets with the Transit Method (DOCX, 1.71 MB)
- Lecture Slides: Detecting Exoplanets with the Transit Method (PPTX, 2.31 MB)

Radio Curriculum

- Lecture-Tutorial: Rotation, Vibration, and Synchrotron Radiation – Astronomical Interactions of Light and Matter (DOCX, 951 KB)
- Lecture Slides: Rotation, Vibration, and Synchrotron Radiation – Astronomical Interactions of Light and Matter (PPTX, 3.94 MB)
- Assessment Questions: Rotation, Vibration, and Synchrotron Radiation – Astronomical Interactions of Light and Matter (DOCX, 695 KB)

Unpublished Ranking Tasks

Apparent & Absolute Magnitude
- Activity 1 (PDF, 151 KB)
- Activity 2 (PDF, 78 KB)
- Activity 3 (PDF, 80 KB)
- Activity 4 (PDF, 70 KB)

Doppler Shift
- Activity 1 (PDF, 145 KB)
- Activity 2 (PDF, 72 KB)
- Activity 3 (PDF, 70 KB)
- Activity 4 (PDF, 68 KB)

Gravity
- Activity 1 (PDF, 95 KB)
- Activity 2 (PDF, 346 KB)
- Activity 3 (PDF, 64 KB)
- Activity 4 (PDF, 287 KB)
- Activity 5 (PDF, 398 KB)
- Activity 6 (PDF, 74 KB)
- Activity 7 (PDF, 116 KB)

Kepler's Laws - Orbital Motion
- Activity 1 (PDF, 170 KB)
- Activity 2 (PDF, 93 KB)
- Activity 3 (PDF, 165 KB)
- Activity 4 (PDF, 70 KB)

Luminosity of Stars
- Activity 1 (PDF, 64 KB)
- Activity 2 (PDF, 72 KB)
- Activity 3 (PDF, 72 KB)
- Activity 4 (PDF, 71 KB)
- Activity 5 (PDF, 67 KB)

Phases of the Moon
- Activity 1 (PDF, 102 KB)
- Activity 2 (PDF, 105 KB)
- Activity 3 (PDF, 84 KB)
- Activity 4 (PDF, 121 KB)
- Activity 5 (PDF, 120 KB)

The Seasons
- Activity 1 (PDF, 223 KB)
- Activity 2 (PDF, 135 KB)
- Activity 3 (PDF, 154 KB)
- Activity 4 (PDF, 198 KB)
- Activity 5 (PDF, 191 KB)

Motion of the Sky
- Activity 1 (PDF, 95 KB)
- Activity 2 (PDF, 96 KB)
- Activity 3 (PDF, 114 KB)
- Activity 4 (PDF, 96 KB)
- Activity 5 (PDF, 114 KB)

Stellar Evolution
- Activity 1 (PDF, 75 KB)
- Activity 2 (PDF, 58 KB)
- Activity 3 (PDF, 74 KB)
- Activity 4 (PDF, 76 KB)

Stellar Evolution & Lookback Time
- Activity 1 (PDF, 69 KB)

Size & Scale
- Activity 1 (PDF, 987 KB)
- Activity 2 (PDF, 1.03 MB)
- Activity 3 (PDF, 67 KB)
- Activity 4 (Word, 29 KB)

NSF: Collaboration of Astronomy Teaching Scholars (CATS)

- Leilani Arthurs, UNL
- Duncan Brown, Syracuse Univ.
- Sanlyn Buxner, Univ. of Arizona
- David Consiglio, Bryn Mawr College
- Tim Chambers, U Michigan
- Steve Desch, Guilford Tech. CC
- Doug Duncan, CU Boulder
- Jeffrey Eckenrode, Pacific Science CTR
- Tom English, Guilford Tech. CC
- John Feldmeier, Youngstown State Univ.
- Amy Forestell Bartholomew, SUNY New Paltz
- Rica French, MiraCosta College
- Adrienne Gauthier, Dartmouth
- Pamela Gay, ASP
- Dennis Hands, High Point Univ.
- Kevin Hardegree-Ullman, University of Toledo
- Melissa Hayes-Gehrke, Univ. of Maryland
- Seth Hornstein, CU Boulder
- David Hudgins, Rockhurst Univ.
- Chris Impey, Univ. of Arizona
- Jessica Kapp, Univ. of Arizona
- John Keller, Cal Poly SLO
- Julia Kregenow, Penn State
- Michelle Wooten, Univ. of Alabama
- Kevin Lee, UNL & NSF
- Patrick Len, Cuesta College
- Chris Lintott, Univ. of Oxford
- Michael LoPresto, Henry Ford CC
- Daniel Loranz, Truckee Meadows CC
- Julie Lutz, Univ. of Washington
- Danny Martino, Santiago Canyon College
- Benjamin Mendelsohn, West Valley College
- Ed Montiel, Louisiana State University
- Peter Newbury, Univ. of British Columbia
- Lee Powell, UN Kearney
- Matthew Price, Ithaca College
- Jordan Raddick, Johns Hopkins Univ.
- Alex Rudolph, Cal Poly - Pomona
- Travis Rector, Univ. of Alaska
- Paul Robinson, Westchester CC
- Wayne Schlingman, Ohio State
- Sébastien Cormier, Grossmont College
- Colin Wallace, UNC
- Kathryn Williamson, NRAO
- James Wysong Jr., Hillsborough CC
- Todd Young, Wayne St. College

CATS
Collaboration of
Astronomy Teaching Scholars
An NSF Funded Center for Astronomy Education (CAE) Program

A little background about me….

- Almost 30 years of research into the teaching and learning of physics and Astronomy

I teach…

…students

…Physics

Desire for students to learn from time in class

Not Important ⟷ Very Important

Desire for class time to be used efficiently

Not Important ⟷ Very Important

Desire for control of the classroom’s directions and actions

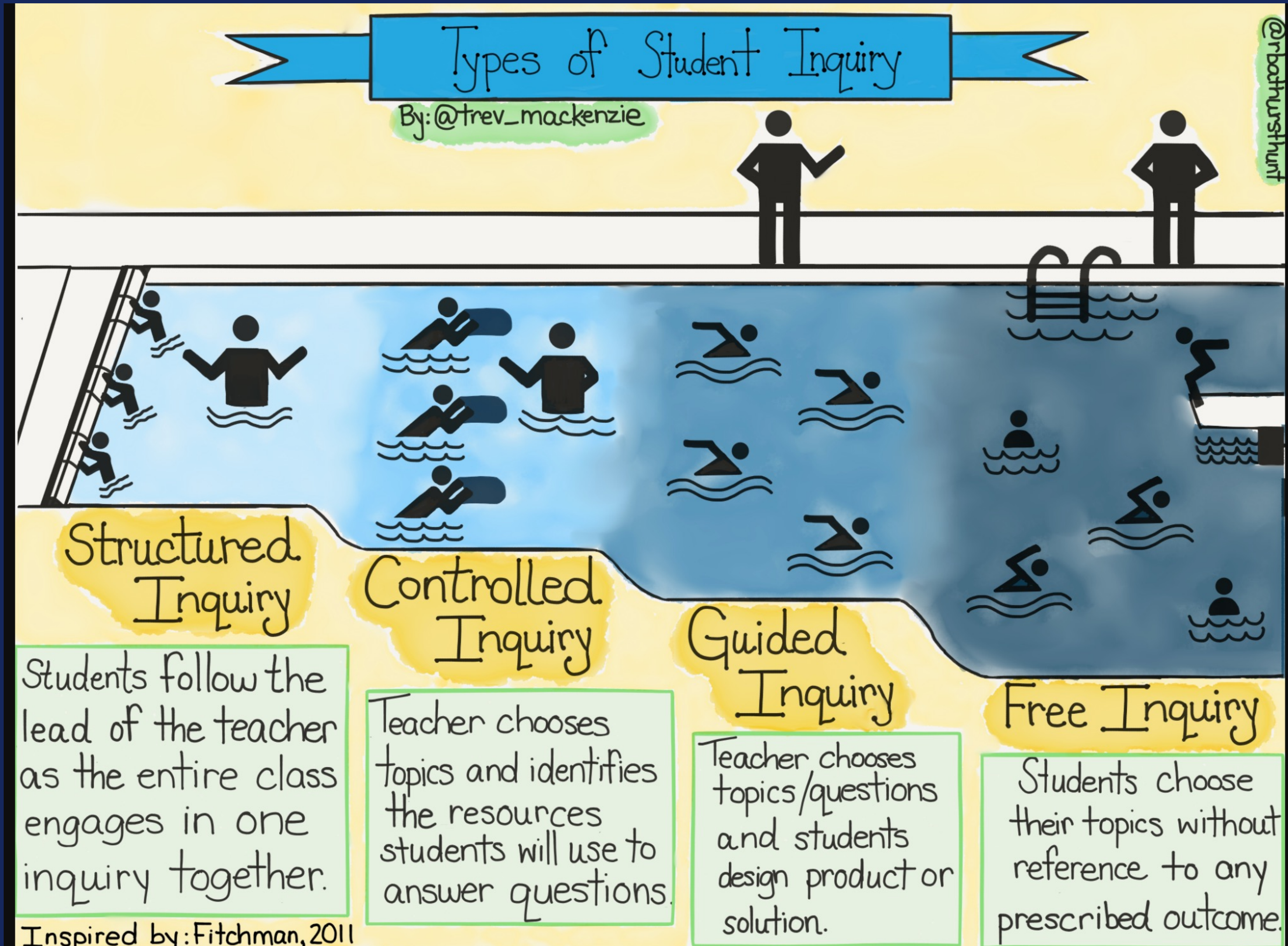
Not Important ⟷ Very Important

Desire for assessments to provide insights and evidence of students’ learning

Not Important ⟷ Very Important

Desire for instructional approach to improve issues related to DEI

Not Important ⟷ Very Important


Types of Student Inquiry
By: @trev_mackenzie
@rbathursthunt
Structured Inquiry
Students follow the lead of the teacher as the entire class engages in one inquiry together.
Controlled Inquiry
Teacher chooses topics and identifies the resources students will use to answer questions.
Guided Inquiry
Teacher chooses topics/questions and students design product or solution.
Free Inquiry
Students choose their topics without reference to any prescribed outcome.
Inspired by: Fitchman, 2011

This will represent "just the tip of the iceberg" of what it takes to create a highly functioning active learning classroom

Getting Our "Challenges" on the Table

- Covering all the content
- Time, time, time!
- Department support
- Teaching resources
- Etc…

The REAL *challenge is* IMPLEMENTATION!!!!

On your own, create a list of:

- All of the actions and moves I might do that go beyond lecture.
- NOT a list of named instructional activities.

You have a couple minutes….. GO.

“Most ideas about teaching are not new, but not everyone knows the old ideas.” Euclid (300 B.C.)

Principles of Teaching and Learning:

1 Prior knowledge and motivation

Connect to students’ prior knowledge and motivations to leverage students’ powerful ideas and interests and attend to where they struggle.

2 Active engagement

Use active engagement so that students do the work of making sense themselves and make meaningful connections.

3 Social interaction

Use social interaction so that students can verbalize their thinking and coach one another.

4 Feedback

Provide feedback opportunities so that students can reflect on and adjust their learning.

5 Inclusive classrooms

Use inclusive classroom strategies to support learning for the widest variety of students.

6 Mastery

Start simple and build up mastery to scaffold students’ understanding so they can build skills and concepts without cognitive overload.

Centennial Hall Performing Arts Theater at University of Arizona

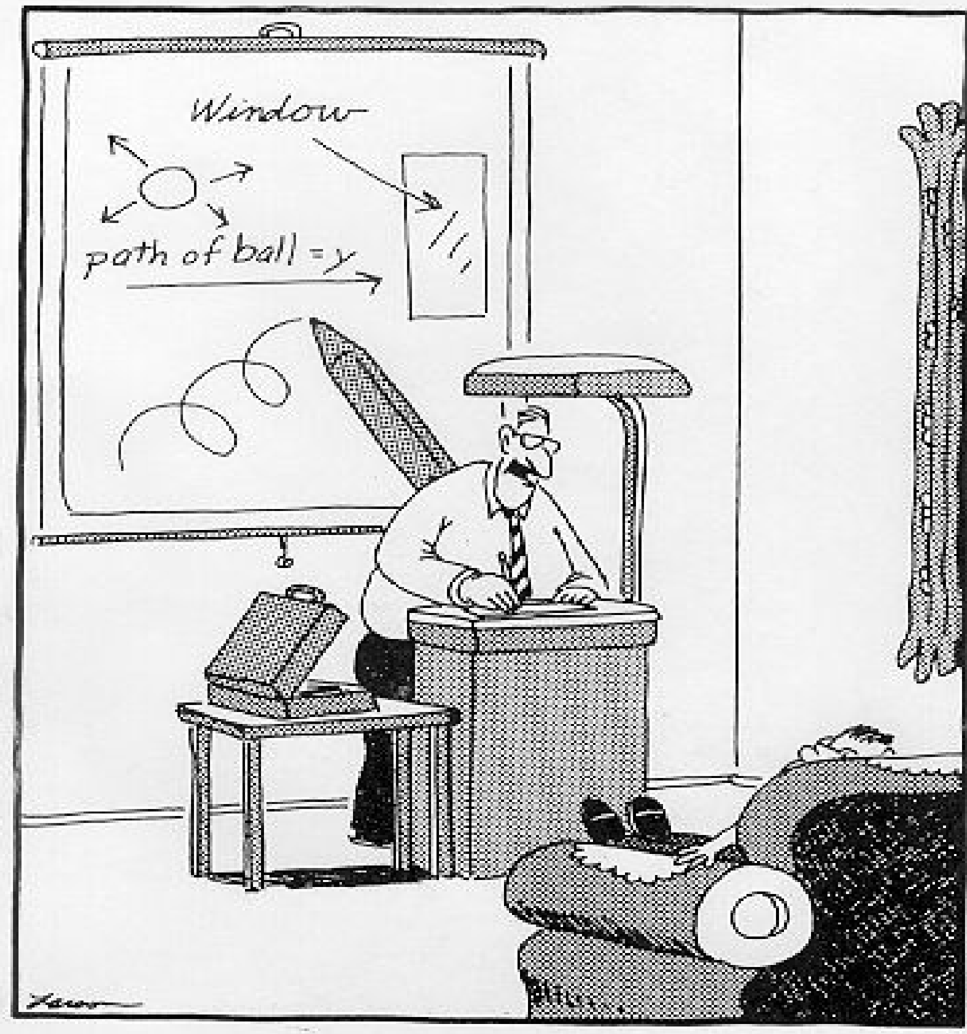
Zongar Buddhist Institute


Where do we live?
On a planet
On a star
On a cloud
On a moon
On a galaxy

If a Picture is worth a thousand words, then what is a real-world, first-hand, experience worth?

Please participate in the role of a good student!

Don't get stuck or caught up in OVER-thinking things!!!!!



Eventually, Billy came to dread his father's lectures over all other forms of punishment.

"Eventually, Billy came to dread his father's lectures over all other forms of punishment"

What Can I do Besides Lecture to Engage Students in their Learning?

- Ask students questions (not all questions are equal)
- In-class writing (with or without discussion)
  - Muddiest Point
  - Summary of Today's Main Points
  - Writing Reflections
- Use interactive videos, demonstrations, animations, and simulations
- Think-Pair-Share or Peer Instruction
- Small Group Interactions
  - Concept Maps
  - Case Studies
  - Sorting Tasks
  - Ranking Tasks
  - Lecture-Tutorials
  - Representation Tasks
- Student Debates (individual/group)
- Whole Class Discussions

Todays Topic:

“Detecting Extrasolar Planets with the Doppler Method”

Please pay attention to:

- How collaboration was encouraged and motivated
- How feedback was incorporated
- The wide range of representations employed
- The sequencing of different intellectual tasks
- The different implementation moves used

Debrief….

I teach…

…students ⟷ …Physics

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Not Important	Desire for students to learn from time in class	Very Important
Not Important	Desire for class time to be used efficiently	Very Important
Not Important	Desire for control of the classroom's directions and actions	Very Important
Not Important	Desire for assessments to provide insights and evidence of students' learning	Very Important
Not Important	Desire for instructional approach to improve issues related to DEI	Very Important

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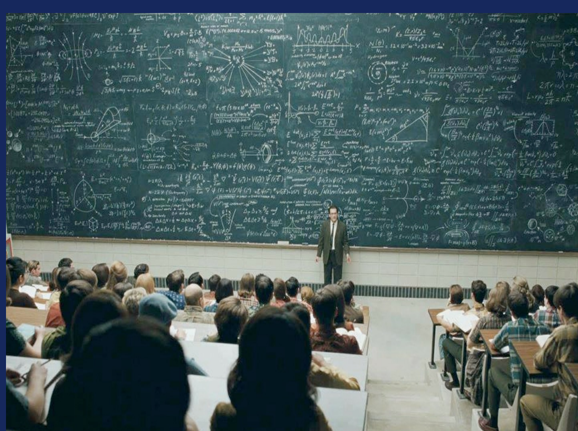
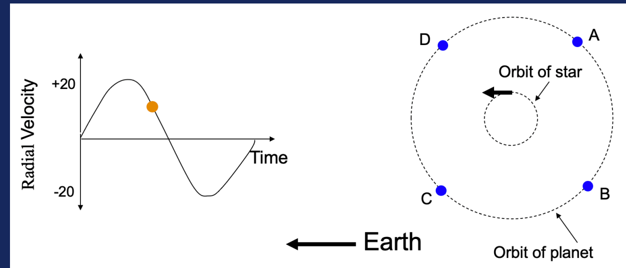
Principles of Teaching and Learning:

1. **Prior knowledge and motivation**
   Connect to students' prior knowledge and motivations to leverage students' powerful ideas and interests and attend to where they struggle.
2. **Active engagement**
   Use active engagement so that students do the work of making sense themselves and make meaningful connections.
3. **Social interaction**
   Use social interaction so that students can verbalize their thinking and coach one another.
4. **Feedback**
   Provide feedback opportunities so that students can reflect on and adjust their learning.
5. **Inclusive classrooms**
   Use inclusive classroom strategies to support learning for the widest variety of students.
6. **Mastery**
   Start simple and build up mastery to scaffold students' understanding so they can build skills and concepts without cognitive overload.

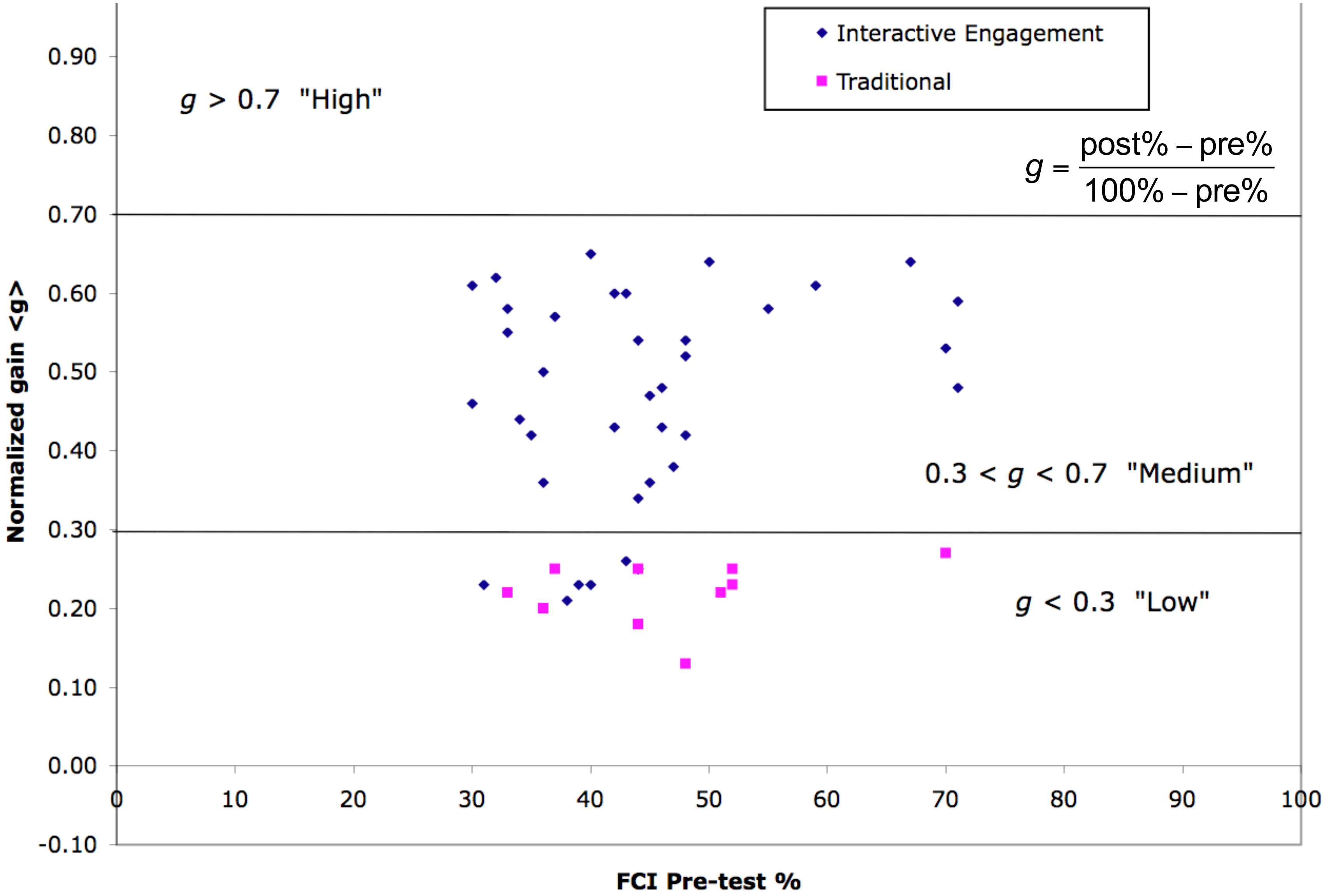




Given the location marked on the star's radial velocity curve, at which location in the planet's orbit would you expect the planet to be?

A little about research results ….

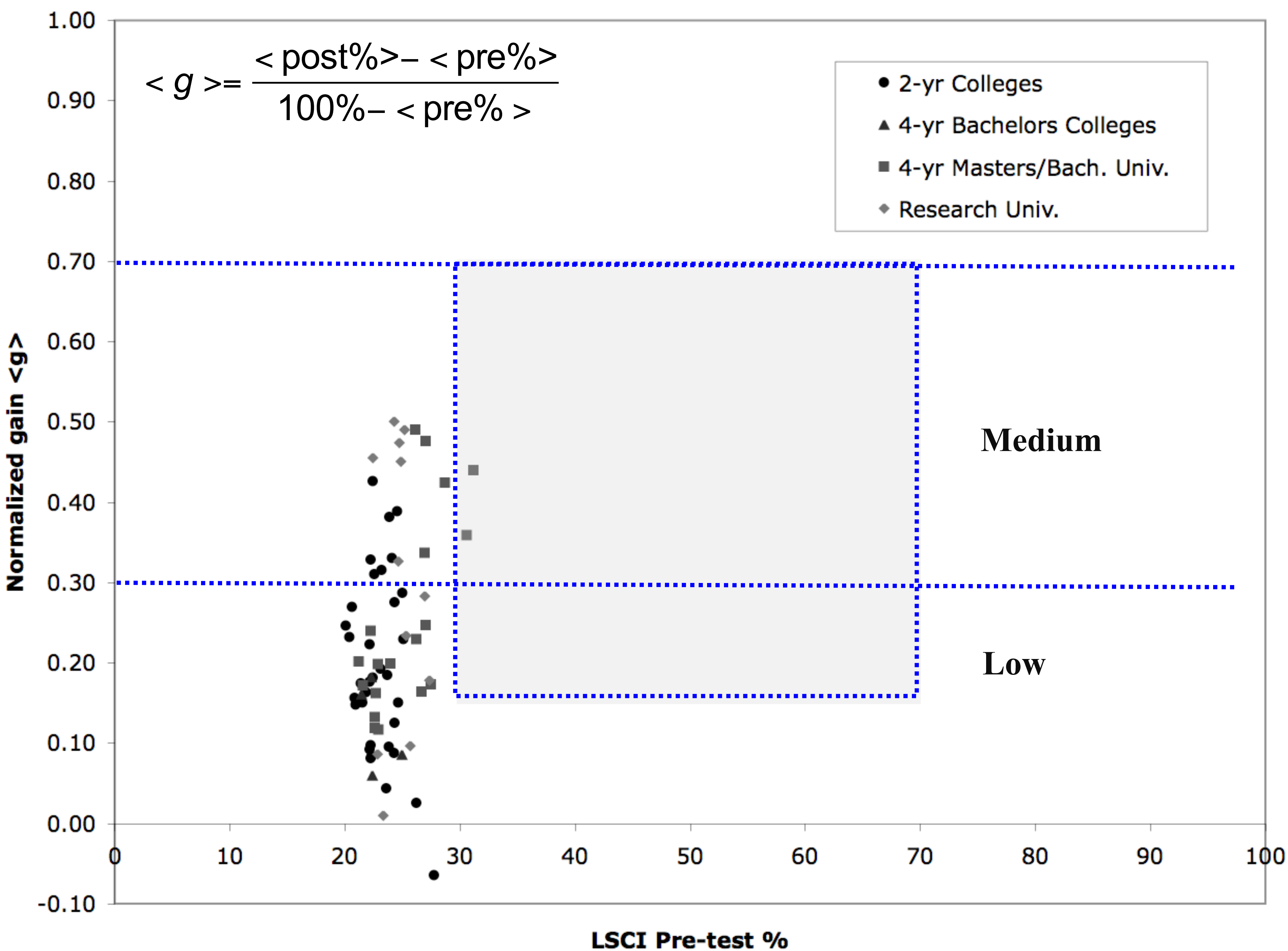
Results from a 6000 student study of Physics Students – *Hake AJP 1998*



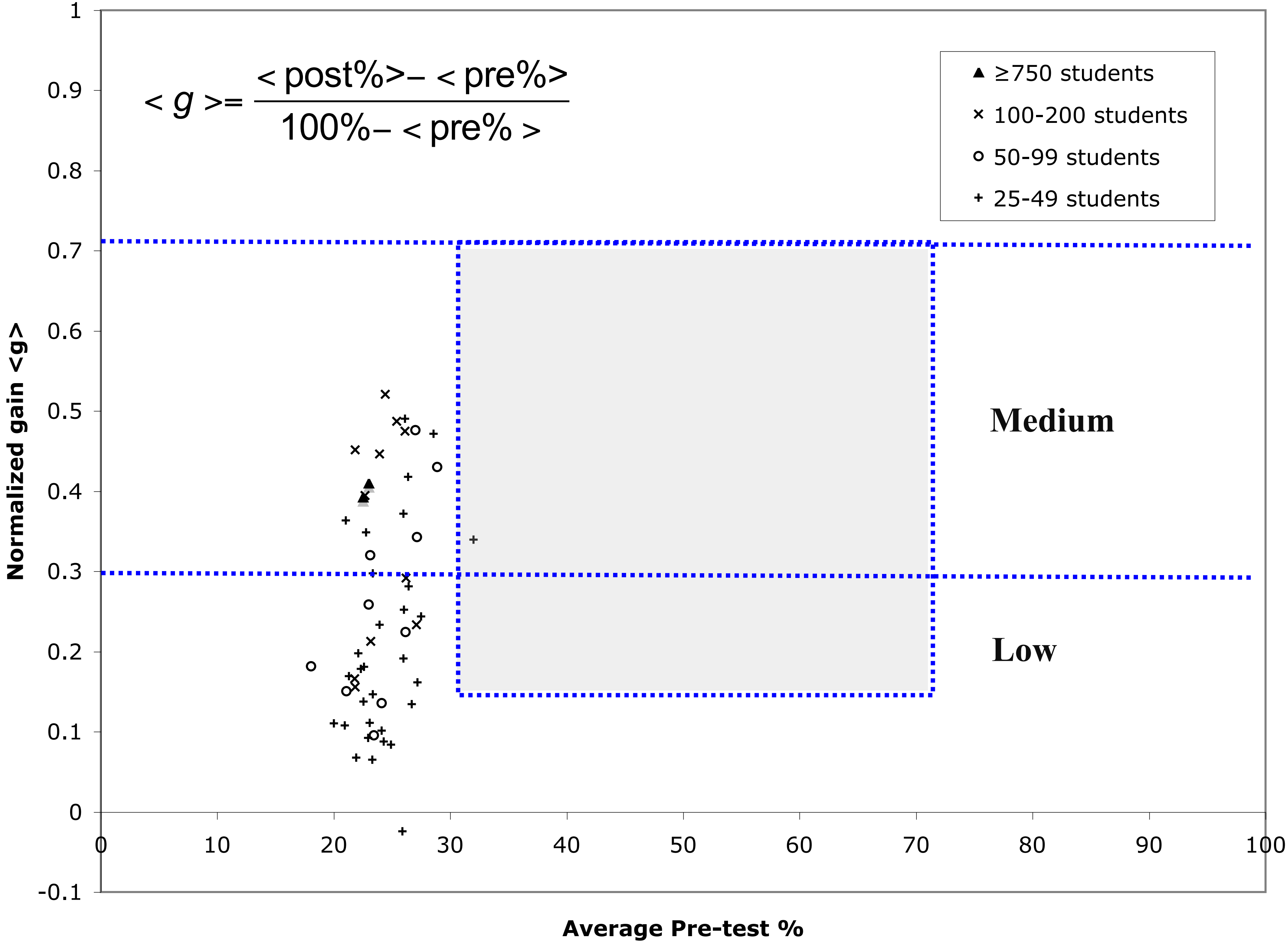
R. Hake, "…A six-thousand-student survey…" AJP 66, 64-74 (1998).

CAE National Study

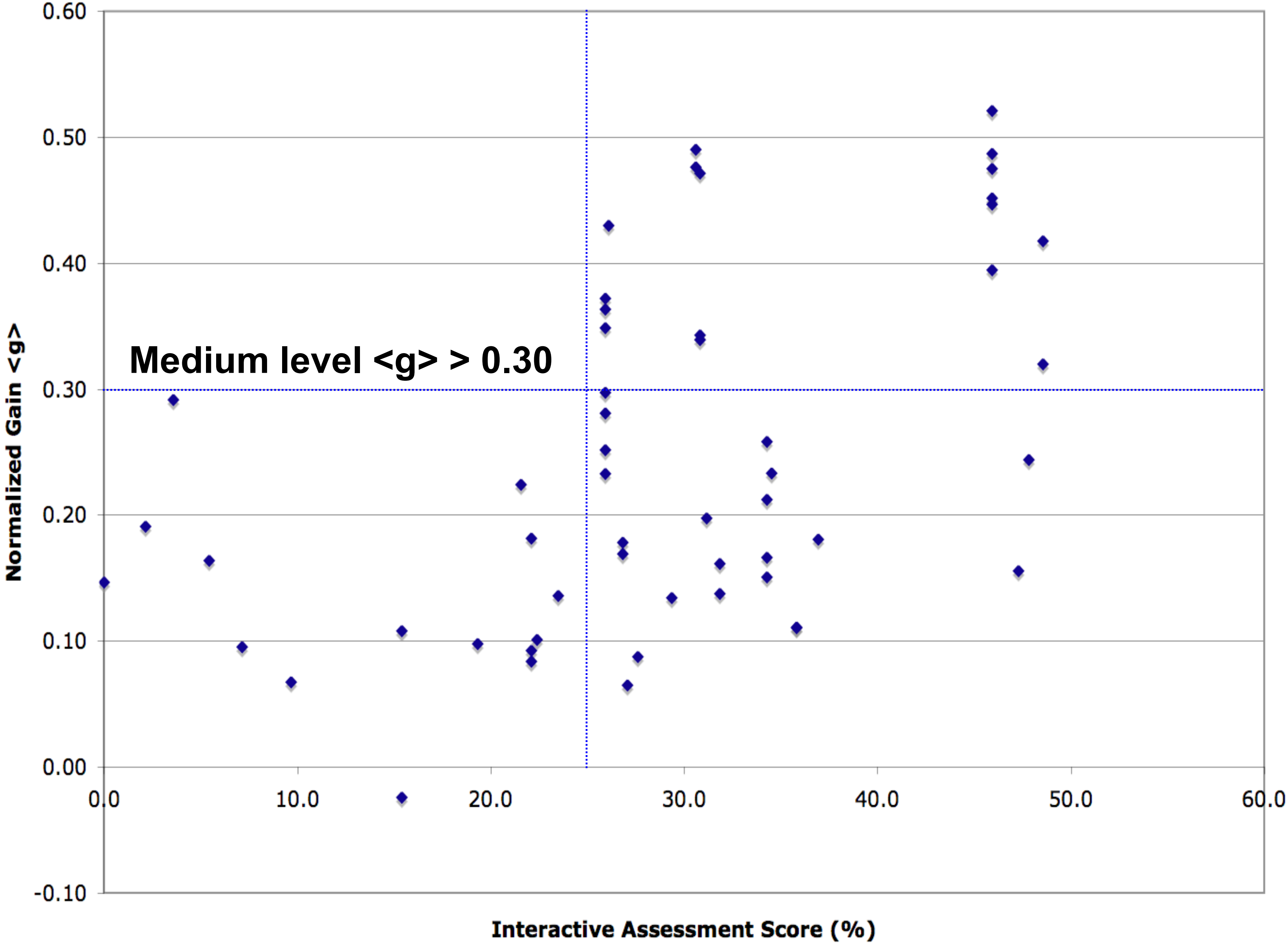
- Almost 4000 students
- 31 institutions
- 36 instructors
- 69 different sections
  - Section sizes vary from <10 to 180 (now with sections >750!)

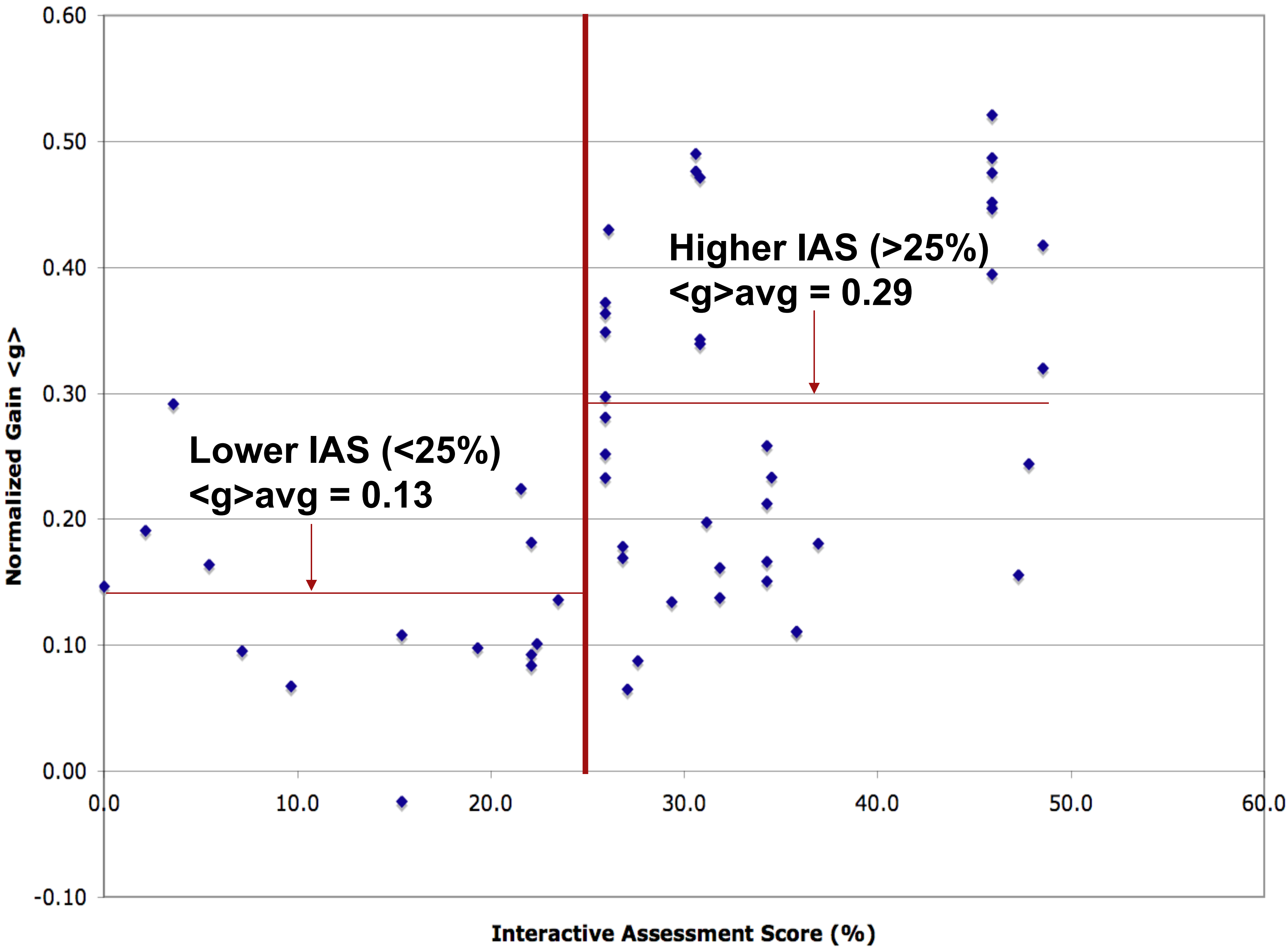


$$\langle g \rangle = \frac{\langle post\% \rangle - \langle pre\% \rangle}{100\% - \langle pre\% \rangle}$$
2-yr Colleges
4-yr Bachelors Colleges
4-yr Masters/Bach. Univ.
Research Univ.
Medium
Low
Normalized gain <g>
LSCI Pre-test %
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
-0.10
0
10
20
30
40
50
60
70
80
90
100



$$\langle g \rangle = \frac{\langle post\% \rangle - \langle pre\% \rangle}{100\% - \langle pre\% \rangle}$$
≥750 students
100-200 students
50-99 students
25-49 students
Medium
Low
Normalized gain <g>
Average Pre-test %
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-0.1
0
10
20
30
40
50
60
70
80
90
100

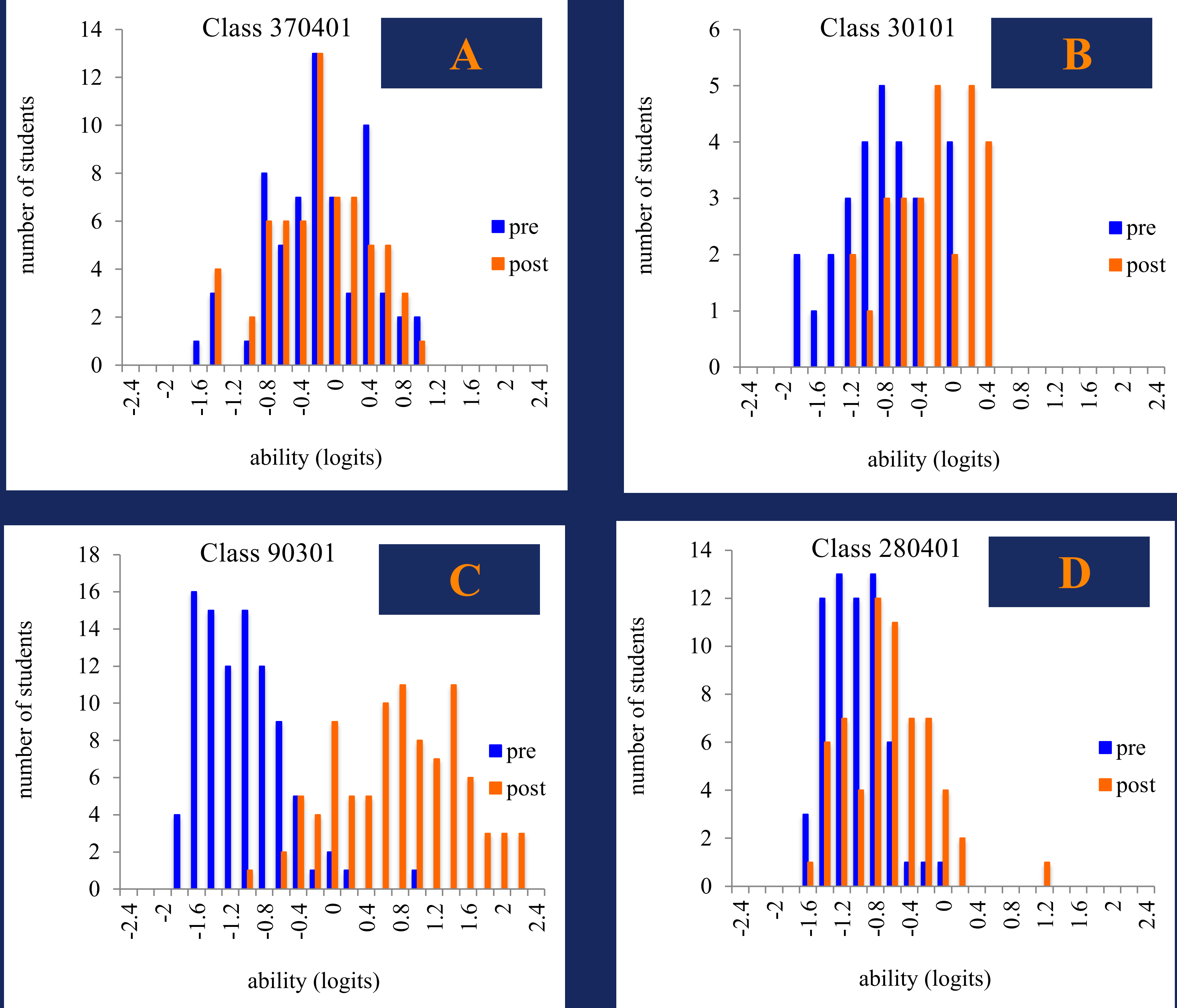

Medium level <g> > 0.30
Normalized Gain <g>
Interactive Assessment Score (%)
0.60
0.50
0.40
0.30
0.20
0.10
0.00
-0.10
0.0
10.0
20.0
30.0
40.0
50.0
60.0



0.60
0.50
0.40
0.30
0.20
0.10
0.00
-0.10
0.0
10.0
20.0
30.0
40.0
50.0
60.0
Normalized Gain <g>
Interactive Assessment Score (%)
Higher IAS (>25%)
<g>avg = 0.29
Lower IAS (<25%)
<g>avg = 0.13

Item Response Theory (IRT)

$$P(X_{pi} = 1 \mid \theta_p, b_i) = \frac{\exp[\theta_p - b_i]}{1 + \exp[\theta_p - b_i]}$$


Class 370401
A
Class 30101
B
Class 90301
C
Class 280401
D
number of students
ability (logits)
pre
post

Demographic Survey

- We also asked 15 demographic questions to allow us to determine how such factors as
  - Gender
  - Ethnicity
  - English as a native language
  - Parental education
  - Overall GPA
  - Major
  - Number of prior science courses
  - Level of mathematical preparation

  interact with instructional context to influence student conceptual learning
- This survey also gives us a snapshot of who is taking Astro 101 in the US

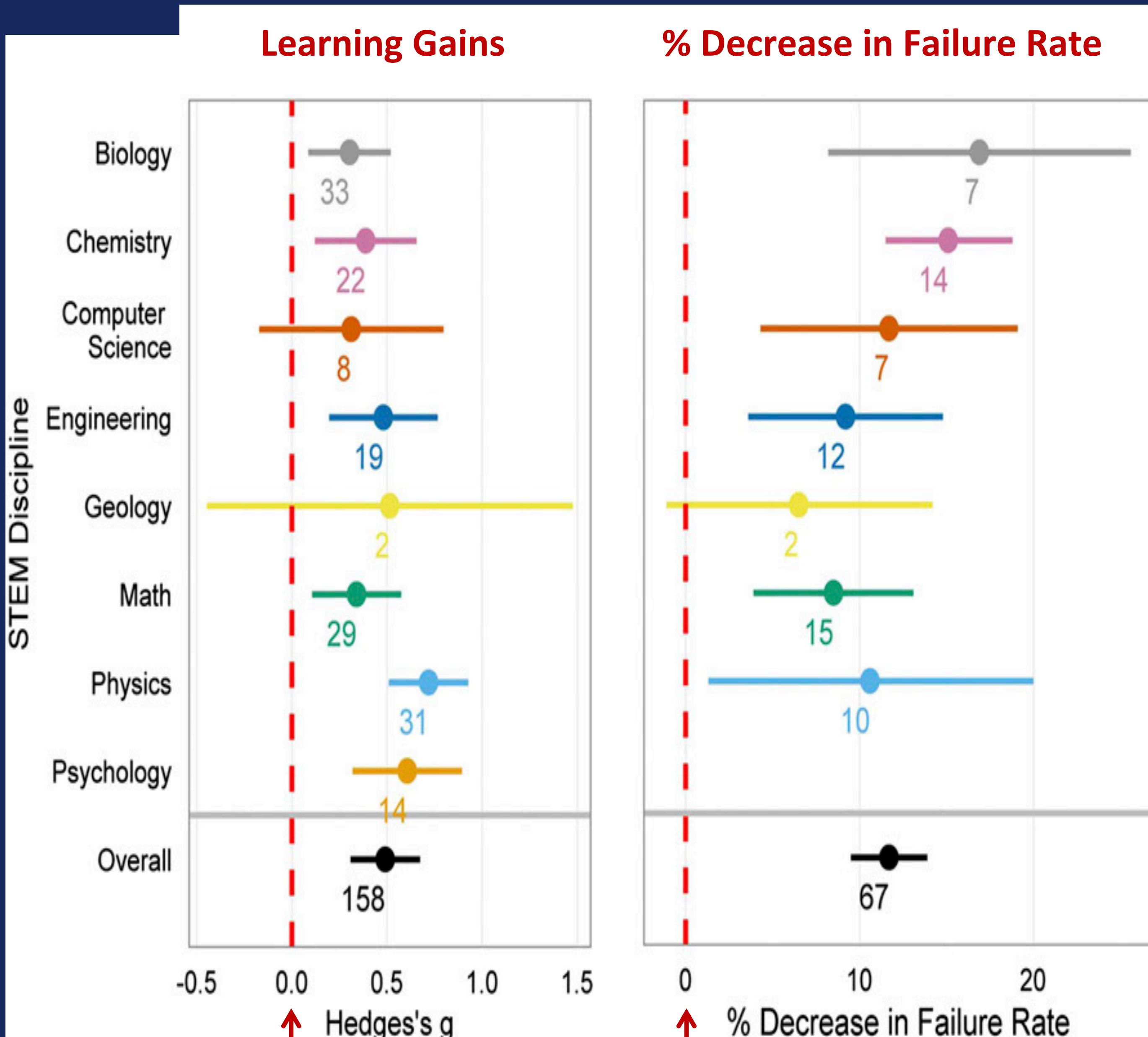
- We conducted a full multivariate modeling analysis of our data
- We confirm that the level of interactivity is the *single most important variable* in explaining the variation in gain, even after controlling for all other variables

The take home message Part II:

The results of our investigation reveal that the positive effects of interactive learning strategies apply equally to men and women, across ethnicities, for students with all levels of prior mathematical preparation and physical science course experience, independent of GPA, and regardless of primary language. These results powerfully illustrate that all categories of students can benefit from the effective implementation of interactive learning strategies.

Take Home Messages

- Research-validated active learning strategies can benefit ALL students in ALL classroom environments - BUT
- The quality of our implementation is likely the most deterministic factor toward student achievement



Numbers indicate # of studies reviewed

traditional lecture class - mean scores

Freeman S et al. PNAS 2014;111:8410-8415

Help People.

If you can't help them,
at least try not to hurt them.

The Dalai Lama