

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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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 development 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](#)

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 \(PDF, 396 KB\)](#)
- [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

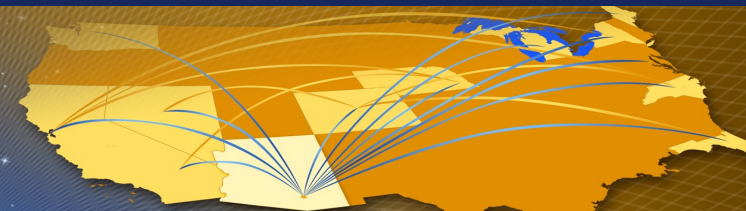
- [Activity 1 \(PDF, 69 KB\)](#)

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
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- Michael LoPresto, Henry Ford CC
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- 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



A little background about...

• Almost 30 years of research and teaching and learning of physics and Astronomy

Research in Teaching

Student Understanding of Ionizing Radiation and Radioactivity Recognizing the Differences Between Irradiation and Contamination

Edward E. Prather and Rachel R. Hartogian

on these topics. The students taking part in this investigation were enrolled in introductory physics courses at the University of Arizona, including the algebra and calculus-based courses, as well as courses for nonscience majors. Typical course enrollment were between 40 and 150 students.

Abstract

Astronomy Education Review

Volume 1, Jul 2002 - Apr 2003
Issue 2

Hints of a Fundamental Misconception in Cosmology

by Edward E. Prather
University of Arizona
Timothy F. Slater
University of Arizona
Erika G. Otterhald
University of Arizona

The Astronomy Education Review, Issue 2, Volume 1:28-34, 2002

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Abstract

To explore the frequency and range of student ideas regarding the Big Bang, nearly 1,000 students from middle school, secondary school, and college were surveyed and asked if they had heard of the Big Bang and, if so, to describe it. In analyzing their responses, we uncovered an unexpected result that more than half of the students who stated that they had heard of the Big Bang also mentioned scenarios that contrast

Abstract

The Astronomy Education Review, Issue 1, Volume 5:11-22, 2007

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Astronomy Education Review

2009, AER, 8, 01011-11, 10.3847/AER0910088

College Students' Preinstructional Ideas About Stars and Star Formation

by Janette M. Bailey
University of Nevada, Las Vegas, Nevada 89154-3005
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Received: 06/04/09, Revised: 06/29/09, Published: 10/14/09

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Abstract

This study (N=1) investigated the beliefs about stars that students hold when they enter an undergraduate introductory astronomy course for nonscience majors. Students' preinstructional ideas were investigated through the use of several student-supplied responses (SSR) surveys, which asked students to describe their ideas about topics such as what is a star, how a star is made, how stars form, and all stars the same, and more. The results from more than 2,200 responses suggest that although students often have some initial knowledge (N=1) and post-instructional knowledge (N=929) from introductory astronomy courses, the United States indicates that the NCEI is composed of items with appropriate difficulty and discriminability and is suitable for this population. Also, expert review and student interventions using the NCEI's validity for the physics population. Emergent similarities and differences in how physics students reason about gravity compared to astronomy students are discussed, as well as future directions for analyzing the instrument's item parameters across both populations. © 2006 American Astronomical Society. 11104-068437

1. INTRODUCTION

As we look into the sky during the daytime, what we see is dominated by the incredibly bright Sun. In its Sun's absence, we see points of light—virtually all of which are stars. The Sun, our closest star, plays a tremendous role in the physical processes on Earth, which allow life to exist. Furthermore, the evolution and patterns of stars have played important roles in human beliefs, primarily through religious, calendar, and mythologies. A tremendous number of stars populate the universe, and the study of their nature and prevalence is a primary subdiscipline of astronomy. Given the importance of stars to our cultural and scientific history, it should come as no surprise that stars are considered a central topic in astronomy.

From a survey of U.S. college syllabi available on the Internet at this time, Sauer et al. (2001) report that stellar evolution ranked in the top ten of the most frequent topics covered in an undergraduate introductory



International Journal of Science Education

Publication details, including instructions for authors and subscription information.
<http://www.tandfonline.com/loi/tjse20>

A Study of General Education Astronomy Students' Understandings of Cosmology. Part V. The Effects of a New Suite of Cosmology Lecture-Tutorials on Students' Conceptual Knowledge

Colin S. Wallace¹, Edward E. Prather² & Douglas K. Duncan³
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Available online: 23 April 2012

A LIVELY ELECTRONIC COMPENDIUM OF RESEARCH, NEWS, RESOURCES, AND OPINION

Astronomy Education Review

Volume 8: Apr 2006 - Nov 2007
Issue 1

Effectiveness of Collaborative Ranking Tasks on Student Understanding of Key Astronomy Concepts

by David W. Hudgins
University of South Africa and Rookhush University
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University of Arizona

Diane J. Grayson
University of Arizona

Derek P. Smeets
University of South Africa

Received: 05/15/06, Revised: 06/20/06, Posted: 07/21/06

The Astronomy Education Review, Issue 1, Volume 5:11-22, 2007

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The Physics Education Research Section (PER) is dedicated to developing important research on the field of physics education research. Manuscripts should be submitted using the web-based system that can be accessed in the American Journal of Physics home page: <http://ajph.education.org> or to PER for consideration.

Applicability of the Newtonian gravity concept inventory to introductory college physics classes

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Stemium State University, Moscow, Missouri 65707
Received 15 April 2015, accepted 21 March 2016

The study described here extends the applicability of the Newtonian Gravity Concept Inventory (NCEI) to college algebra-based physics classes, beyond the general education astronomy courses for which it was originally developed. The four conceptual domains probed by the NCEI (Dimensionality, Force Law, Independence of Other Forces, and Inertia) are well suited for investigating students' reasoning about gravity in both populations, making the NCEI a highly versatile instrument. Classical test theory statistical analysis with physics student responses pre-instruction (N=1192) and post-instruction (N=929) from introductory astronomy courses at the United States indicates that the NCEI is composed of items with appropriate difficulty and discriminability and is suitable for this population. Also, expert review and student interventions using the NCEI's validity for the physics population. Emergent similarities and differences in how physics students reason about gravity compared to astronomy students are discussed, as well as future directions for analyzing the instrument's item parameters across both populations. © 2006 American Astronomical Society. 11104-068437

CONSTRUCTION. This construction points that learners incorporate new knowledge into existing mental landscapes, and that they can provide to maintain learning, maintain what they know of their own "mental landscape" and that they can order students with opportunities for "cognitive dissonance." Students' existing mental landscapes can be described as "knowledge in pieces," organized as generative mental structures, or "the more generalized" mental model "to a robust and coherent knowledge element or strongly associated set of knowledge elements." Taking a scholarly approach to studying students' disciplinary knowledge development, researchers in physics education and astronomy education have spent considerable time developing models and valid instruments with critical disciplinary topics. Pre- and post-instructional testing with group-based and valid instruments with critical disciplinary topics. Pre- and post-instructional testing with a large scale leading to profound insights and evidence for assessing physics and astronomy teaching and learning on a large scale leading to profound insights and evidence for assessing physics and astronomy teaching and learning on a large scale. In this paper, we build on the literature and provide new valid and meaningful instruments for introductory algebra-based students' conceptual understanding.

Teaching and learning astronomy in the 21st century

Edward E. Prather, Alexander L. Rudolph, and Gina Brissoni

A national study of teaching and learning in courses that introduce astronomy to nonscience majors shows that interactive learning strategies significantly improve student understanding of core concepts in introductory astronomy.

Edward E. Prather is executive director of the Center for Astronomy Education (CAE) at the University of Arizona's Steward Observatory in Tucson, Arizona. He is also a professor of physics at the University of Arizona. Alexander L. Rudolph is a professor of physics at the University of California State Polytechnic University in Pomona, California. Gina Brissoni is a professor of physics at the University of Arizona.

A LIVELY ELECTRONIC COMPENDIUM OF RESEARCH, NEWS, RESOURCES, AND OPINION

Astronomy Education Review

Volume 7, Aug 2008 - Jan 2009
Issue 2

Development and Application of a Situated Apprenticeship Approach to Professional Development of Astronomy Instructors

by Edward E. Prather
University of Arizona
Gina Brissoni
University of Arizona
Received: 08/21/08, Revised: 10/06/08, Posted: 12/22/08

The Astronomy Education Review, Issue 2, Volume 7:11-17, 2009

© 2008, Edward Prather. Copyright assigned to the Association of Universities for Research in Astronomy, Inc.

Abstract
Professional development for astronomy instructors largely focuses on enhancing their understanding of the limitations of professor-centered lectures while also increasing awareness and better implementation of learning strategies that promote a learner-centered classroom environment. Given how difficult it is to get instructors to implement well-developed and innovative teaching ideas, even when these instructors are supplied with significant and compelling education research data, one must wonder what is missing from most commonly used professional development experiences. This article proposes a learner-centered approach to professional development for college instructors, which we call *situated apprenticeship*. This novel approach properly goes beyond simple awareness building and conventional modeling, challenging instructors to actively engage themselves in practicing teaching strategies in an environment of peer review in which participants offer suggestions and critiques of each other's implementations. Through this learner-centered teaching and evaluation experience, instructors' presencing conceptual and pedagogical understandings of a particular instructional strategy are brought forth and examined in an effort to promote a real change of practice that positively impacts both their core pedagogical content knowledge and their skills in successfully implementing these teaching strategies. We believe that adoption of our situated apprenticeship approach for professional development will increase the frequency and success of college instructors' implementation of research-validated instructional strategies for interactive learning.

Making Science Personal: Inclusivity-Driven Design for General-Education Courses

Chaitany O'Donnell¹, Edward Prather¹, & Peter Beharav²
¹ Department of Astronomy and Thermal Observatory, University of Arizona, Tucson, AZ 85721, USA

Abstract
General-education college astronomy courses often lack instruction both a unique audience and a unique challenge. For many students, such a course may be their first time encountering a non-science astronomy class, and it is also likely one of the last science courses they will take. Thus, in a single semester, primary course goals often include both imparting knowledge about the universe and giving students some familiarity with the processes of science. In traditional course environments, students often compartmentalize information into separate "life-like" and "science-like" sections that impede understanding of the science. The astronomy course created through this project, taught at the University of Arizona in Spring 2010, was designed around inclusivity-driven guiding principles that help students respond with course content to their own personal interests and experiences. After courses before the course

A LIVELY ELECTRONIC COMPENDIUM OF RESEARCH, NEWS, RESOURCES, AND OPINION

Astronomy Education Review

2013, AER, 12(1), 010101, <http://dx.doi.org/10.3847/AER1301042>

Astro 101 Students' Perceptions of Science: Results from the Thinking About Science Survey Instrument

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Edward E. Prather
Center for Astronomy Education (CAE), Steward Observatory, University of Arizona, Tucson, Arizona 85721
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Received: 08/01/12, Accepted: 01/14/13, Published: 02/15/13

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Abstract

What are the underlying worldviews and beliefs about the role of science in society held by students enrolled in a college-level, general education, introductory astronomy course (Astro 101)—and are those beliefs affected by active engagement instruction? Studies have shown that students' conceptual knowledge and reasoning abilities related to astronomy. To help answer this question, we administered Columbia's (2011) Thinking About Science Survey Instrument (TSSI) to about 1000 classes in the spring 2011. The TSSI probes students' beliefs about the relationship between science and many aspects of contemporary society. In this paper, we analyze the 442 pre-instruction and 294 post-instruction student responses we received for the TSSI. Many students select responses to the TSSI's items indicating they have positive views about the role of science in society. We also see a slight increase in the number of positive responses pre- to post-instruction. There are limitations to the inferences one can draw from responses to a Likert scale survey such as the TSSI, but nevertheless provides an important first step in a larger project to understand and affect the worldviews of general education, introductory astronomy students. To better interpret the significance of these results, we conclude by comparing the TSSI data to preliminary data from a related study in which we collected students' written responses to a series of prescriptive, open-ended prompts on the relationship between science and society.

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I teach...



...students

...Physics



Center for Astronomy Education

» Dedicated to the professional development of introductory astronomy instructors

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**

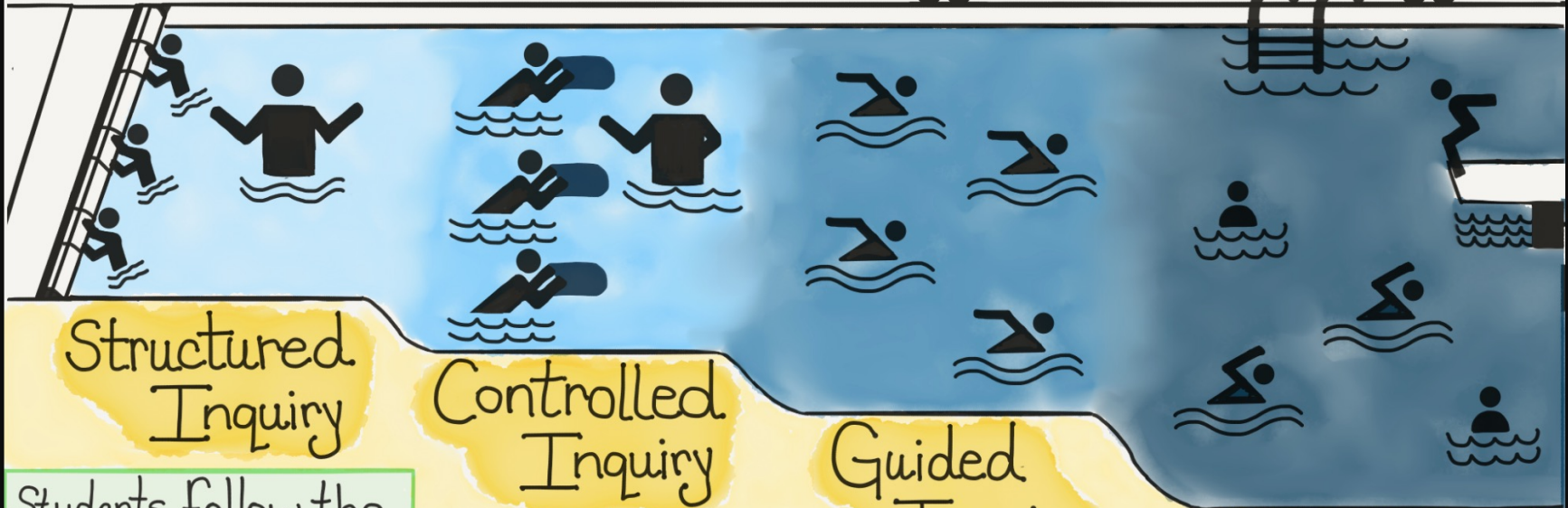
Not Important ← **Desire for instructional approach to improve issues related to DEI** → **Very Important**



Types of Student Inquiry

By: @trev_mackenzie

@rbathursthurl



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.

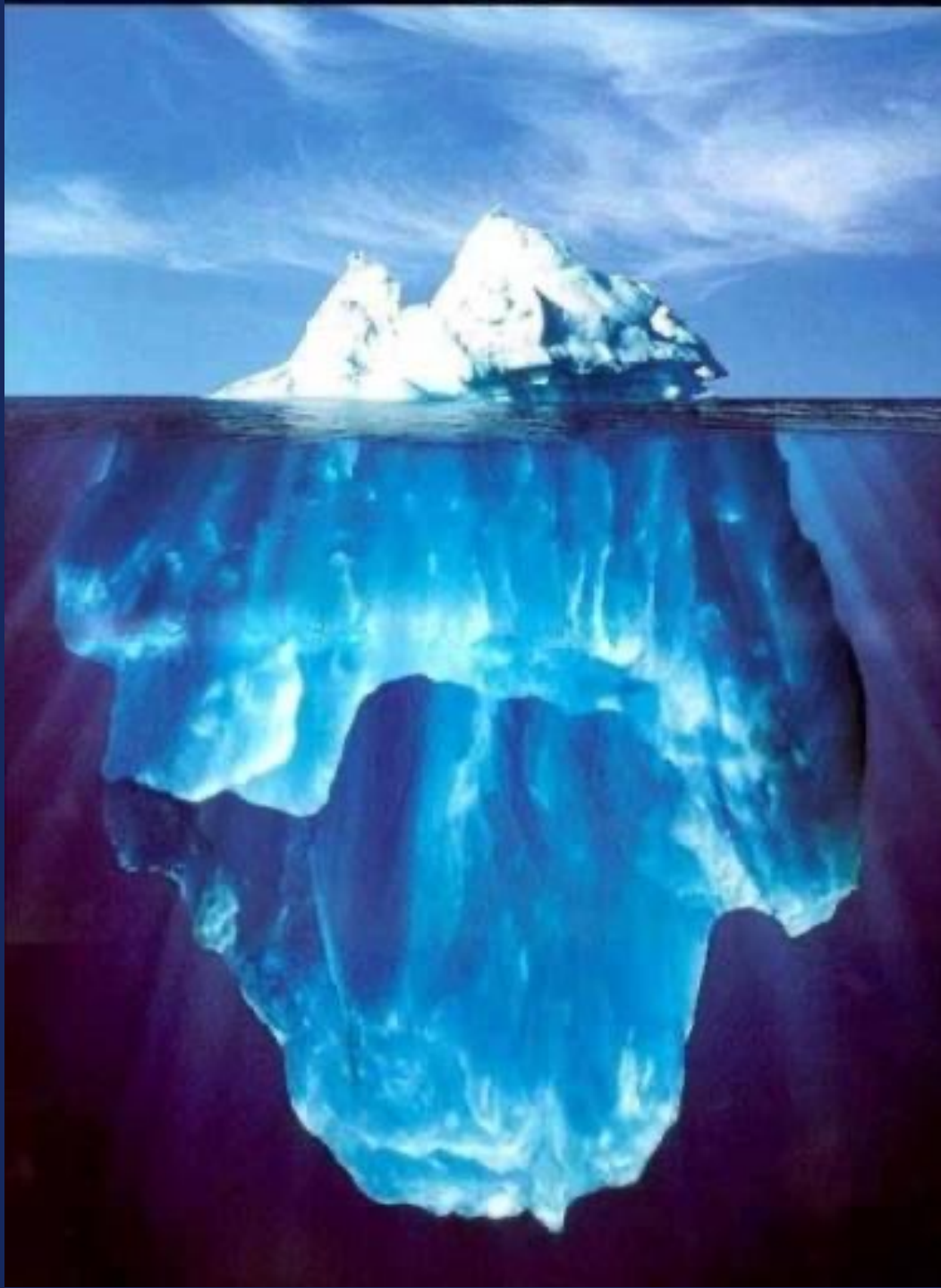
Guided Inquiry

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.)**



Center for Astronomy Education

» Dedicated to the professional development of introductory astronomy instructors

A banner for the Center for Astronomy Education. The background is a dark blue space scene with a large orange and yellow planet on the left and a bright star with a purple and blue nebula on the right. The text "Center for Astronomy Education" is written in white, and below it, a smaller line of text reads "» Dedicated to the professional development of introductory astronomy instructors".

A large blackboard filled with handwritten mathematical notes and diagrams, likely related to physics or mathematics. The content includes:

- Diagrams of wave patterns and vector fields.
- Equations such as $N(\theta) = 32 \times 10^{-1} \text{ m}^{-2} = 32 \times 10^2 \text{ m}^{-2}$.
- Formulas for energy and power, including $E = \frac{1}{2} \rho v^2 A^2$ and $P = \frac{1}{2} \rho v^2 A^2 v$.
- Trigonometric and calculus expressions like $\frac{d}{dt} \int_{-\infty}^{\infty} \psi^2 dx$.
- Diagrams of a lens and a right-angled triangle.
- Various other mathematical derivations and definitions.



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.



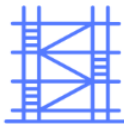
4 Feedback

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



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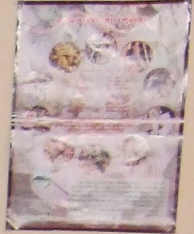
Zongar Buddhist Institute







कैरी पर संवत्सरा संकट

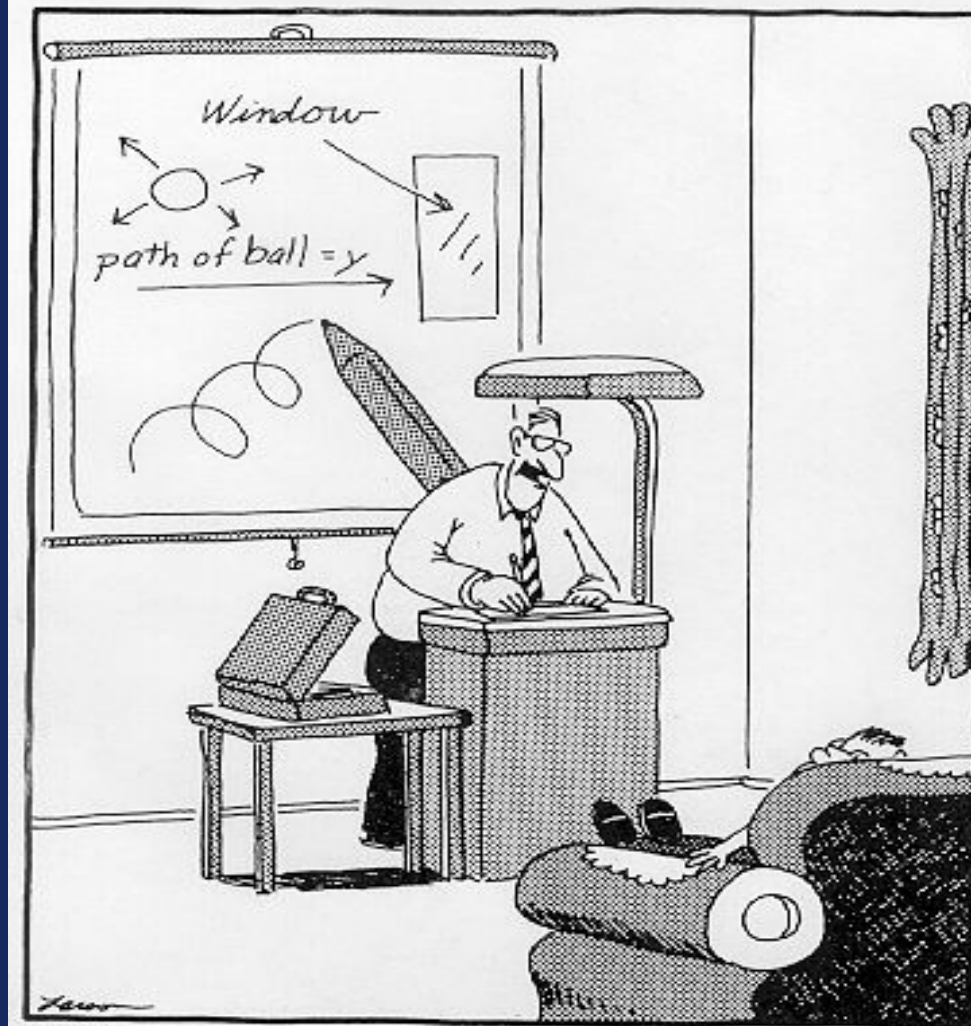


Where do we live?
On a planet
On a star
On a cloud
On a moon
On a galaxy

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

Today's 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



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I teach...

...students

...Physics

Debrief....

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.

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.

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

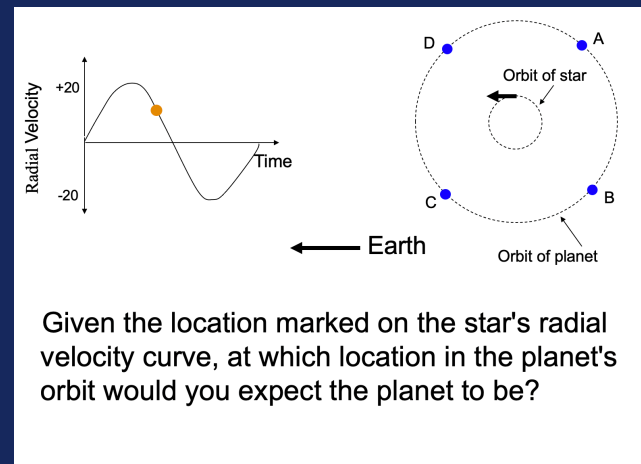
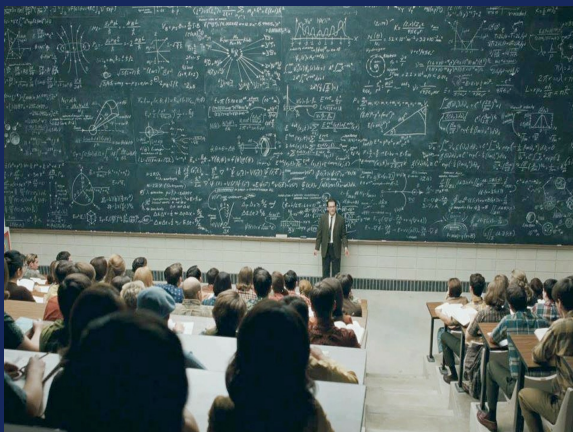
Not Important ← Desire for control of the classroom's directions and actions → Very Important

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



17



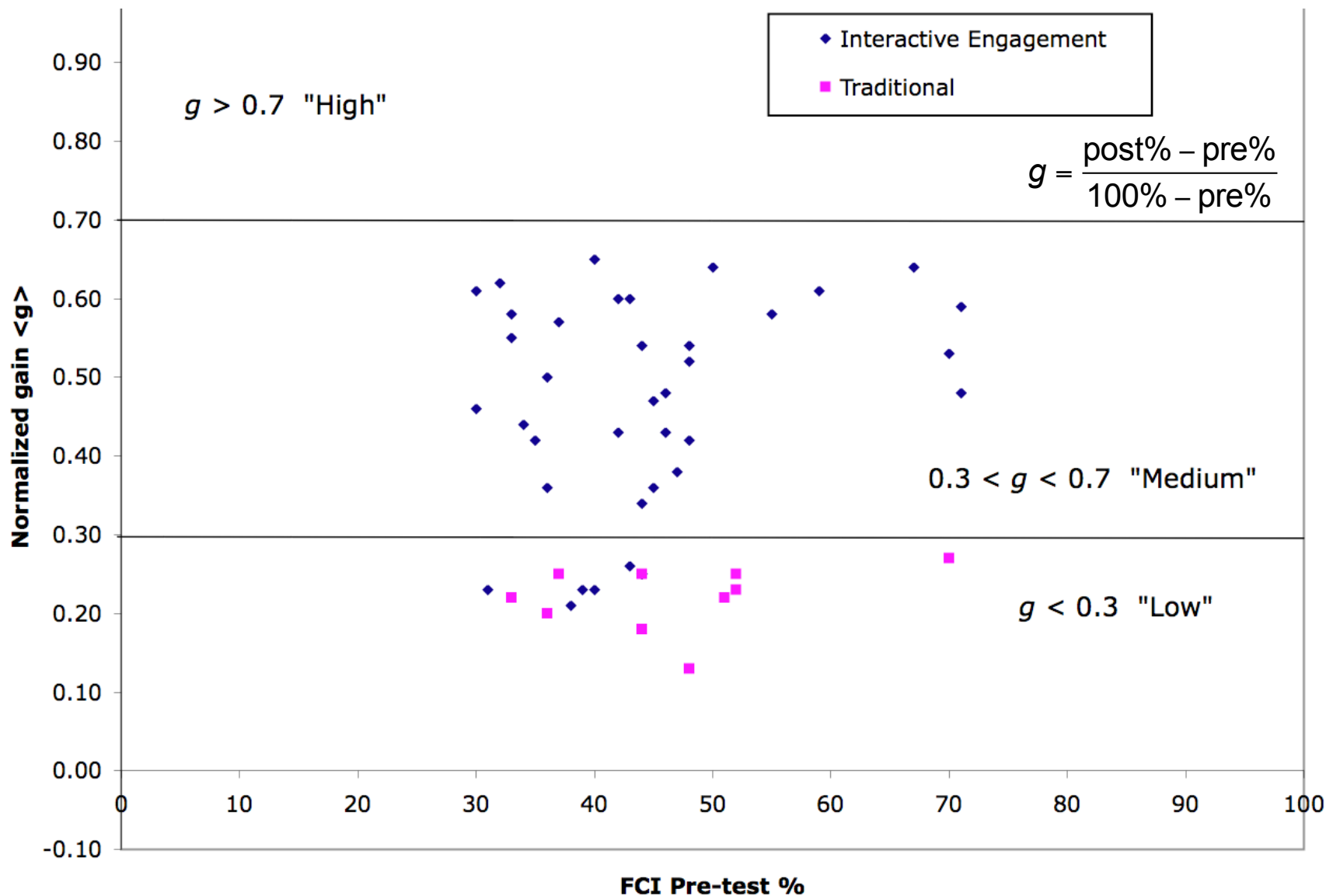
A little about research results



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

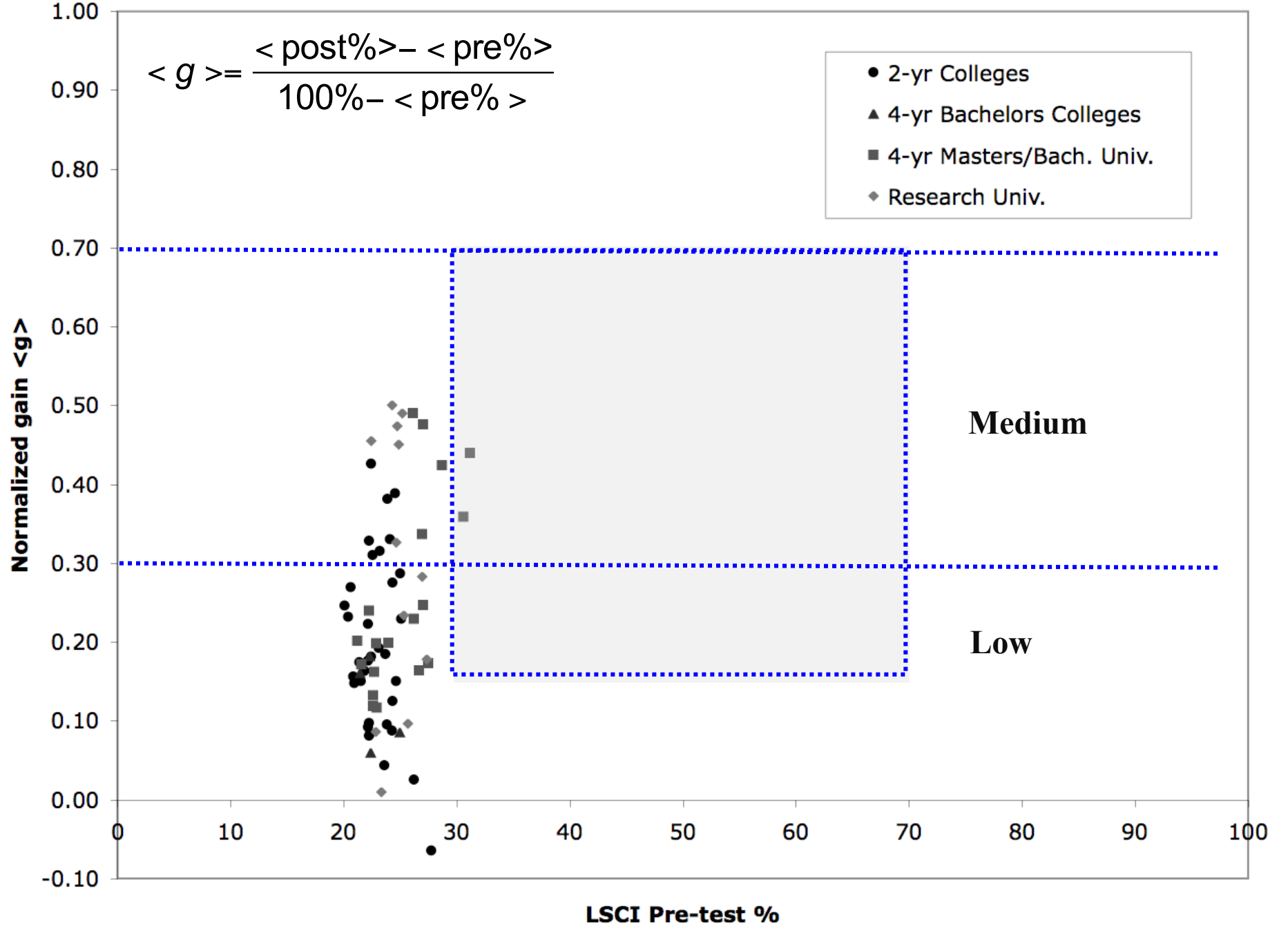


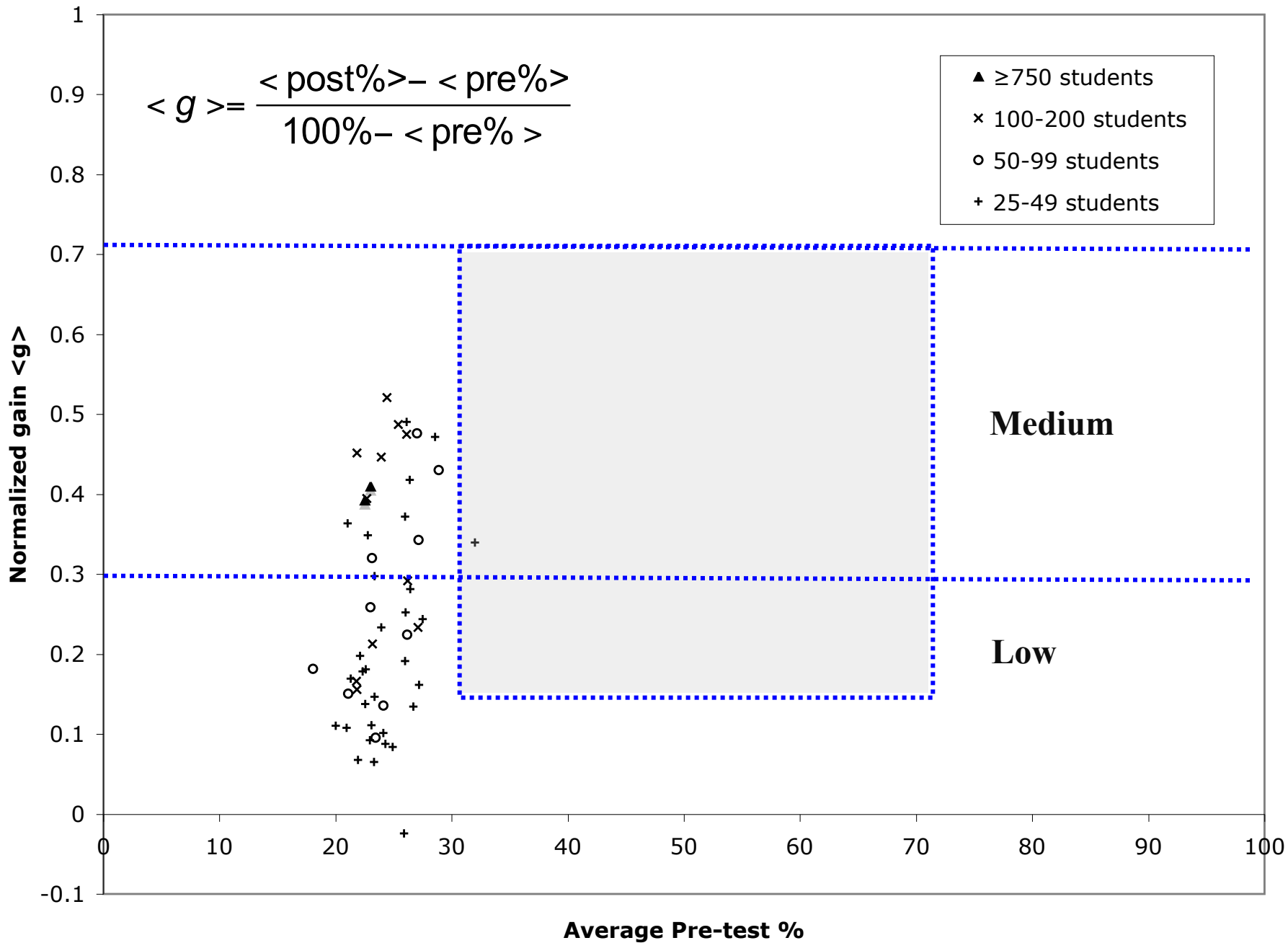
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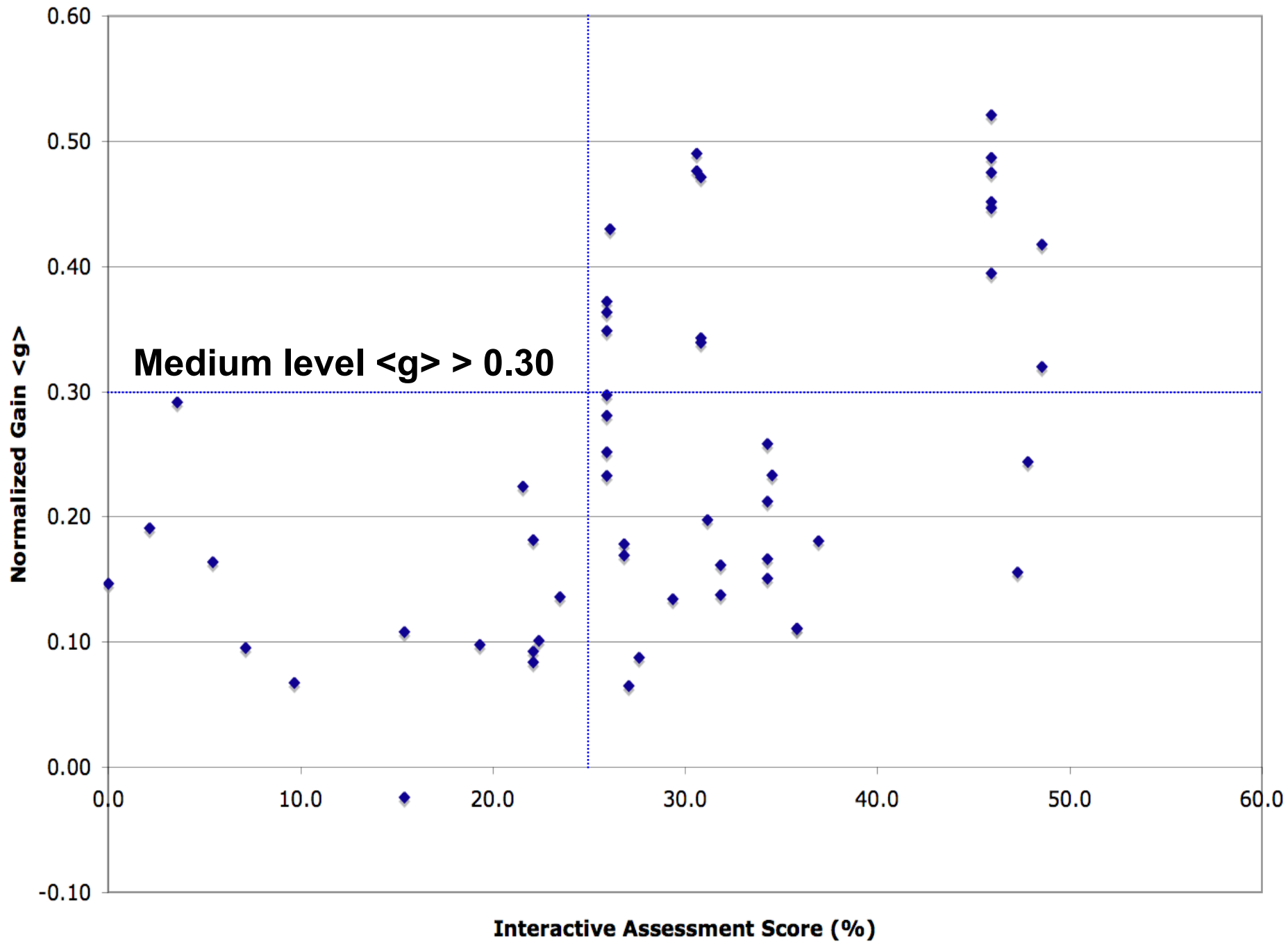
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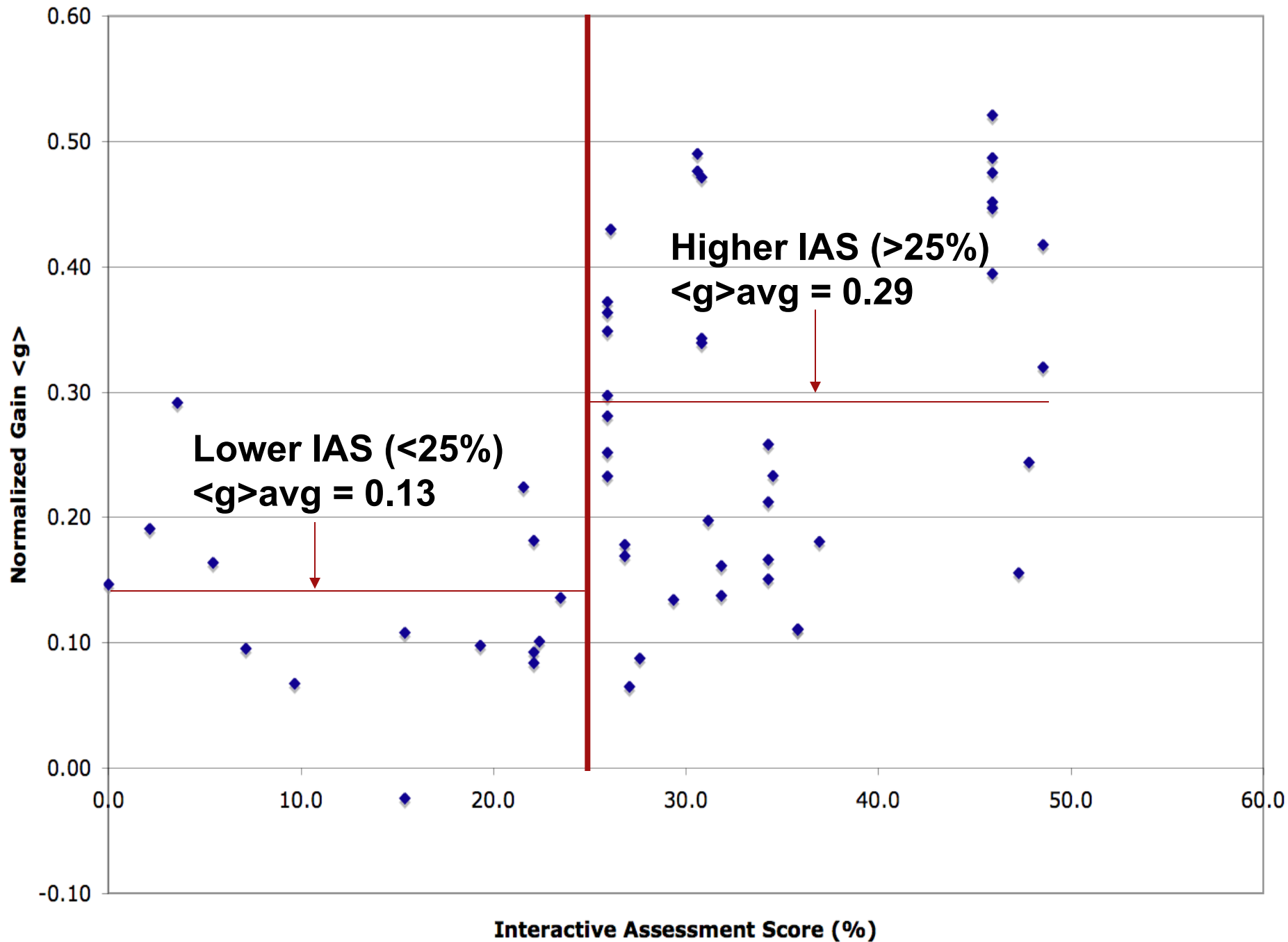
$$\langle g \rangle = \frac{\langle \text{post}\% \rangle - \langle \text{pre}\% \rangle}{100\% - \langle \text{pre}\% \rangle}$$

- 2-yr Colleges
- ▲ 4-yr Bachelors Colleges
- 4-yr Masters/Bach. Univ.
- ◆ Research Univ.



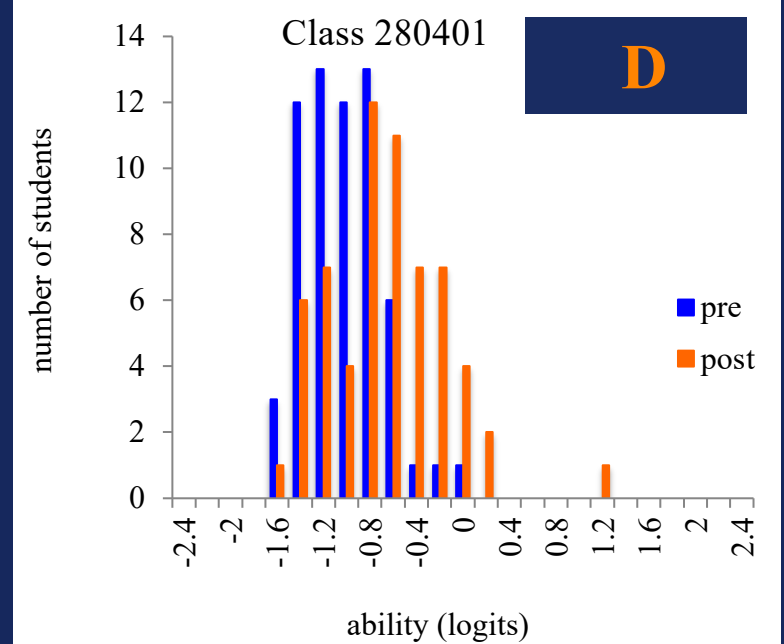
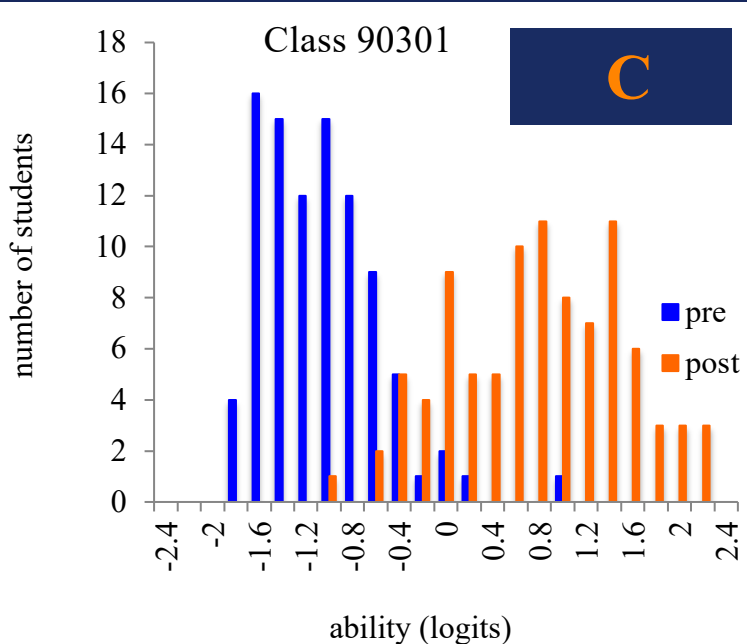
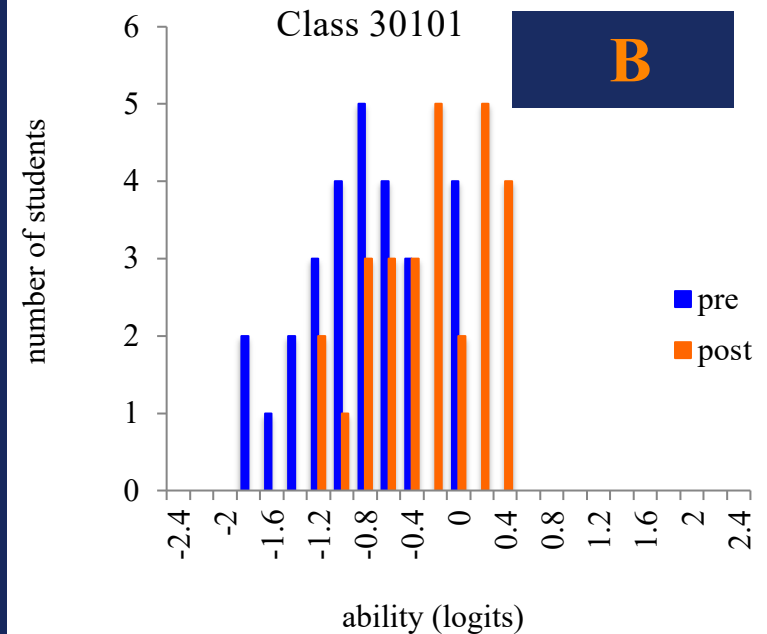
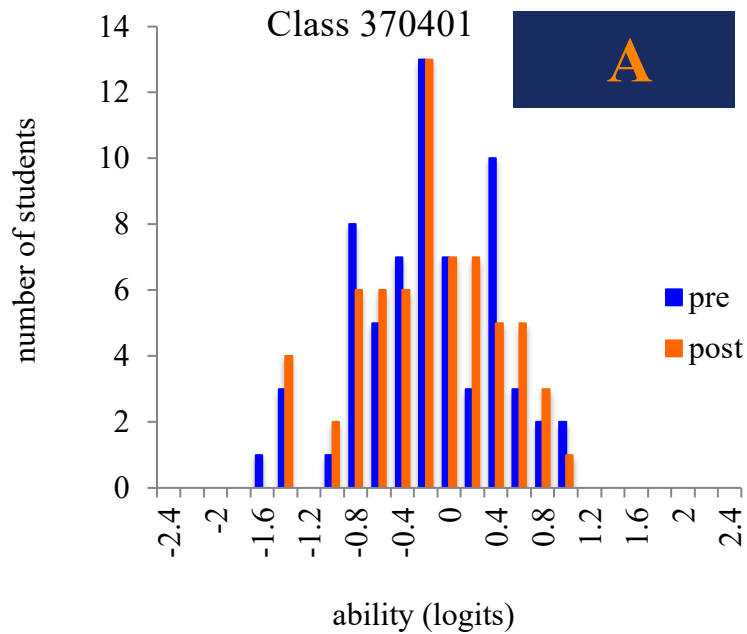






Item Response Theory (IRT)

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

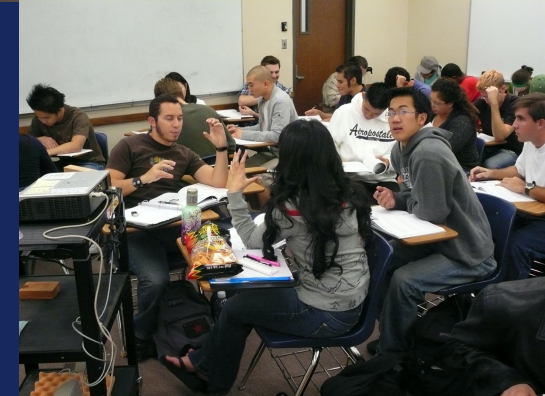


Demographic Survey

- 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



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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

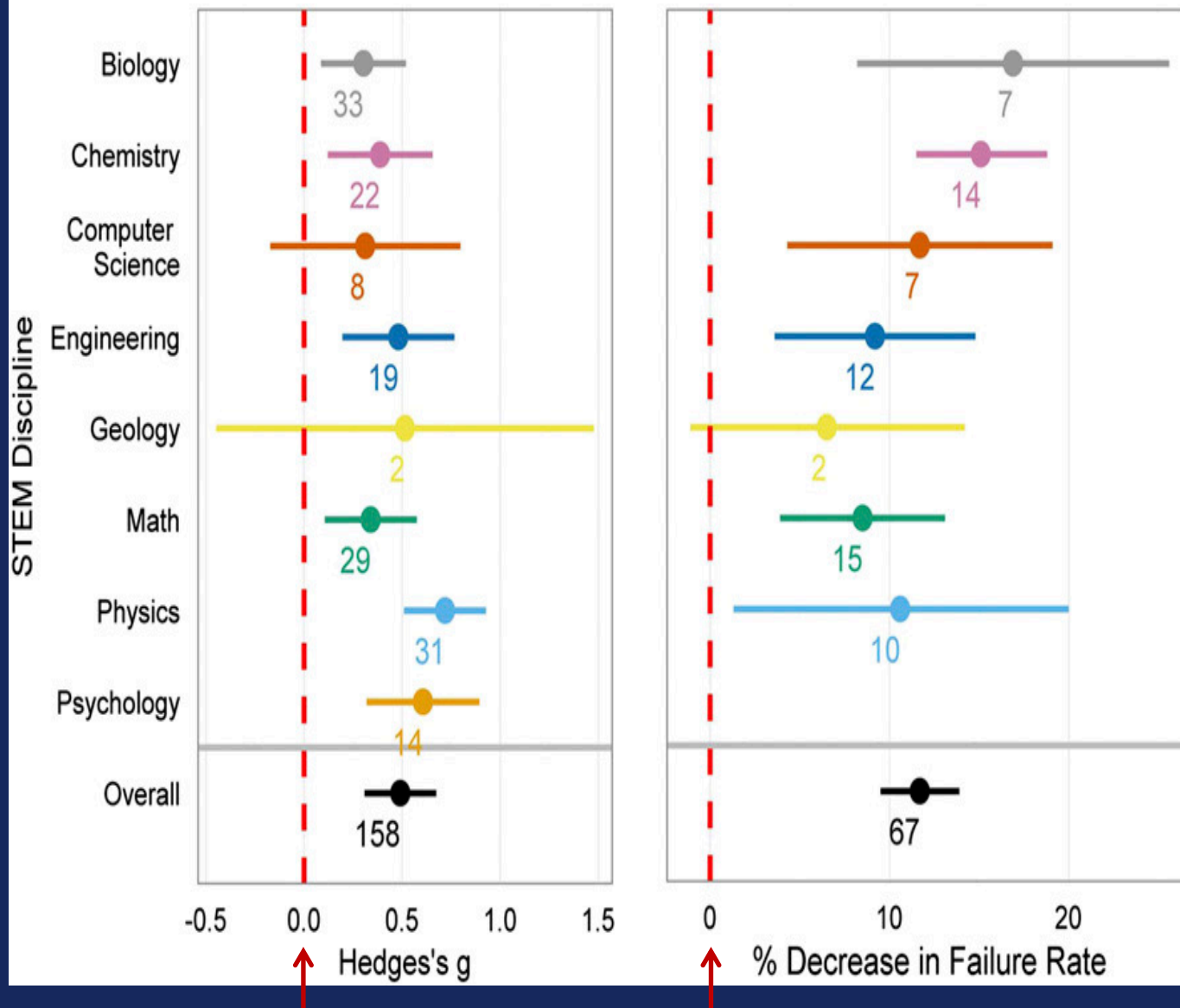


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Learning Gains

% Decrease in Failure Rate



Numbers indicate # of studies reviewed

↑ traditional lecture class - mean scores

Help People.

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

The Dalai Lama



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