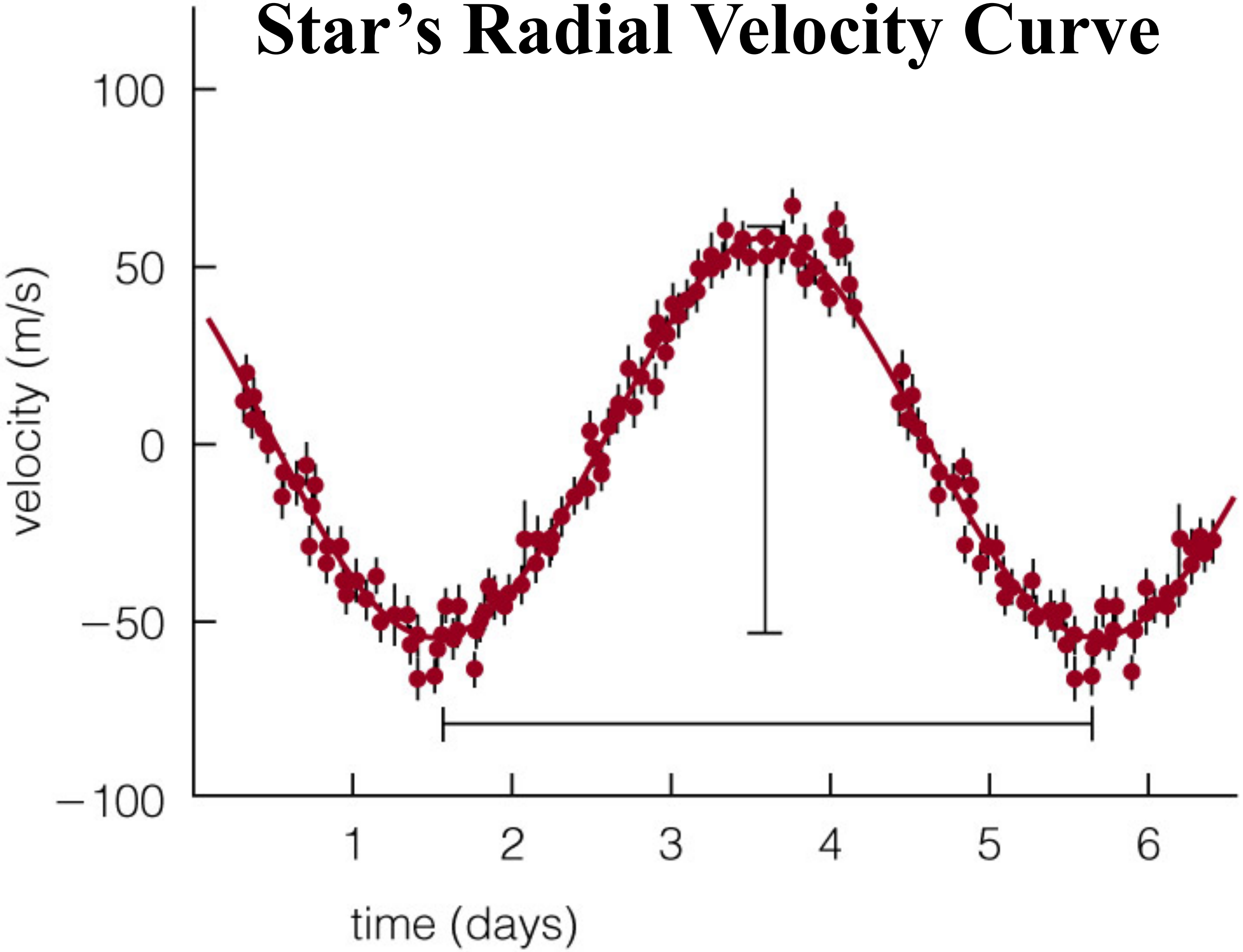
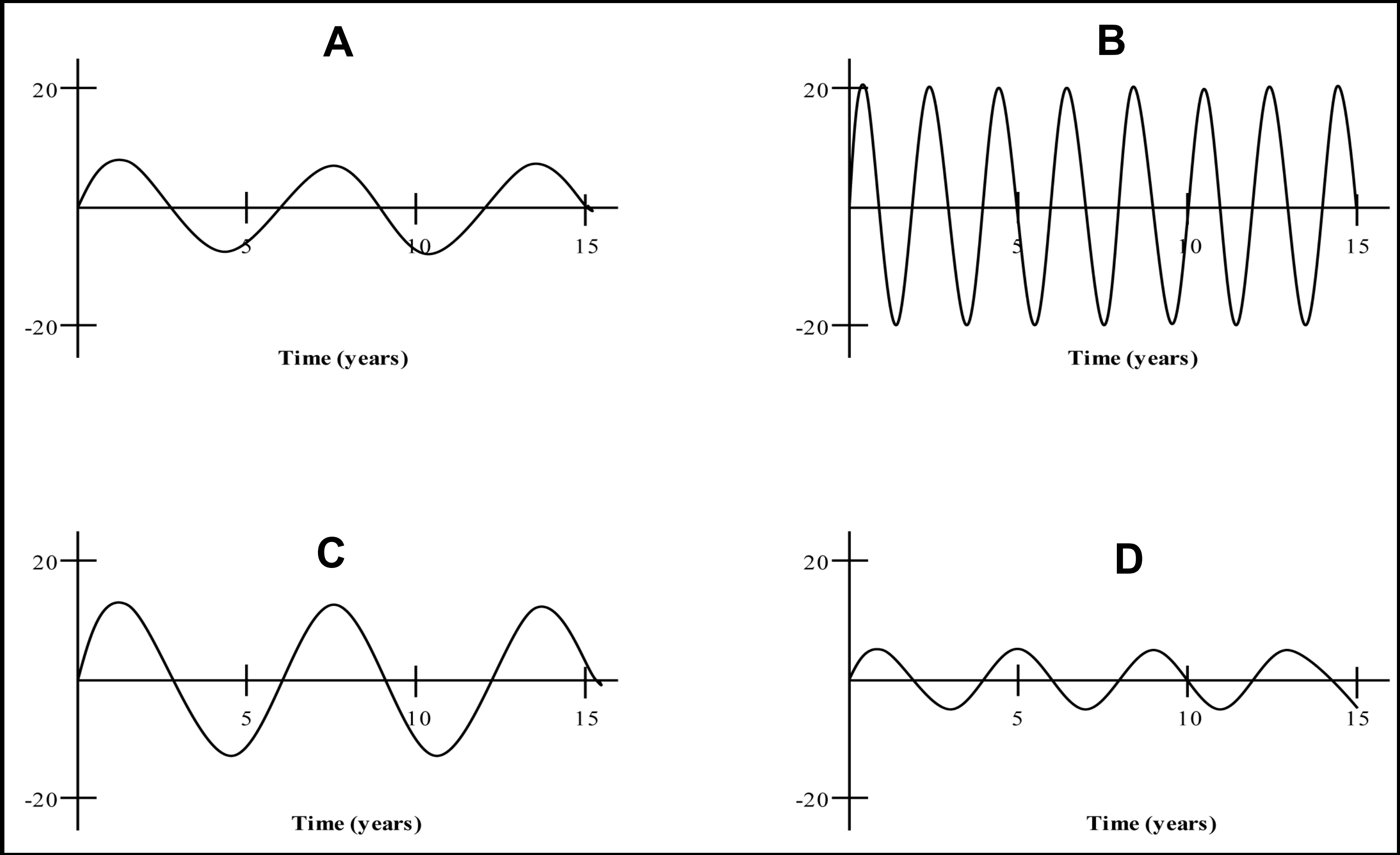
Star's Radial Velocity Curve



Shown below are the radial velocity vs time graphs for four stars in different extrasolar planet systems (A-D).

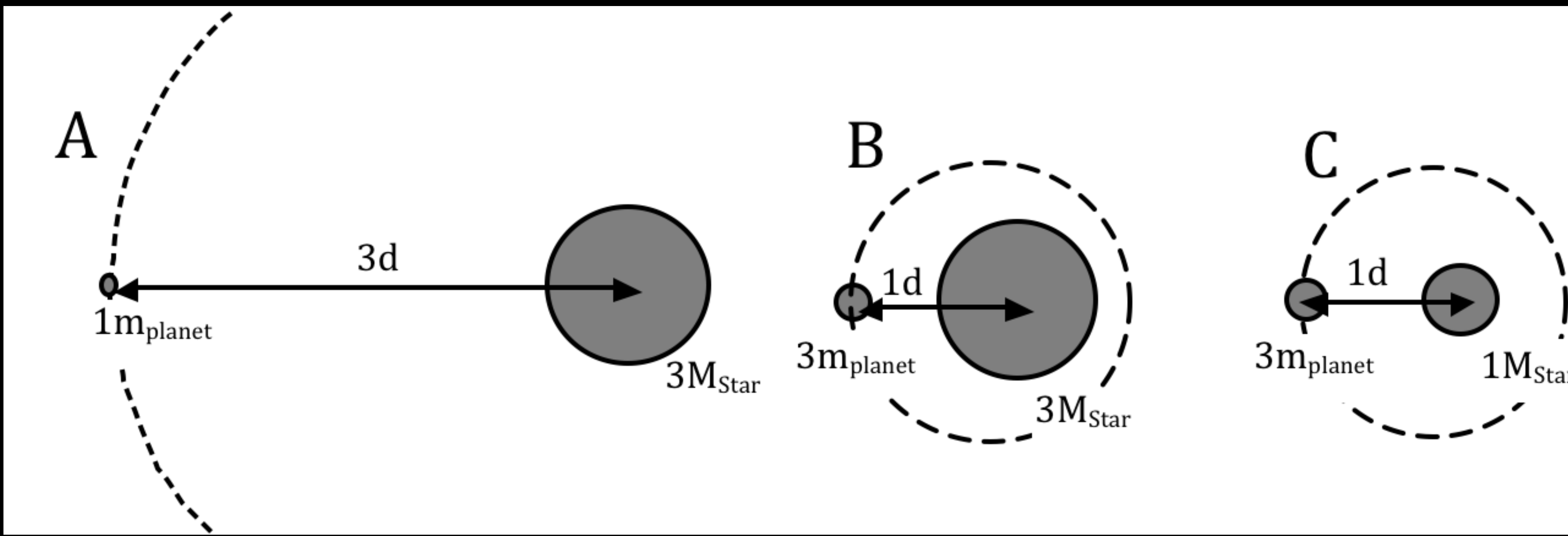
In which system would we detect the greatest amount of Doppler Shift in the Star's light?

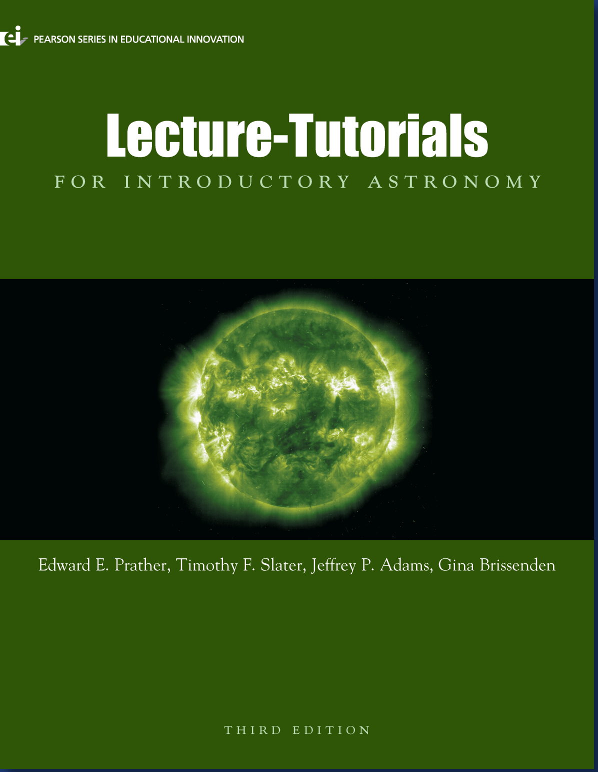


It is hardest to detect a planet in an extrasolar planet system when

A. a low mass planet is far from a low mass star.
B. a high mass planet is close to a high mass star.
C. a high mass planet is far from a low mass star.
D. a low mass planet is close to a high mass star
E. a low mass planet is far from a high mass star.

Shown below are three extrasolar planet systems (A-C). In which system would we detect the greatest amount of Doppler Shift in the Star’s light?





Lecture-Tutorials:

Post-lecture, pencil and paper activities, that use a Socratic-dialogue driven, highly-structured collaborative learning methodology to help students elicit, confront and resolve their naïve beliefs and reasoning difficulties, and improve their critical thinking skills and develop scientifically robust conceptual models.

Research on a Lecture-Tutorial Approach to Teaching Introductory Astronomy for Non–Science Majors, Prather, E. E.; Slater, T. F.; Adams, J. P.; Bailey, J. M.; Jones, L. V.; Dostal, J. A., Astronomy Education Review, 3(2) 2005

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

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

What you are likely to hear (and see) from them:

- Can you help us?
- Were stuck.
- We don't know what it's asking us.
- Is this right?
- Were confused about _____.
- Does it mean _______ or _______?
- Do we need to worry about ______?

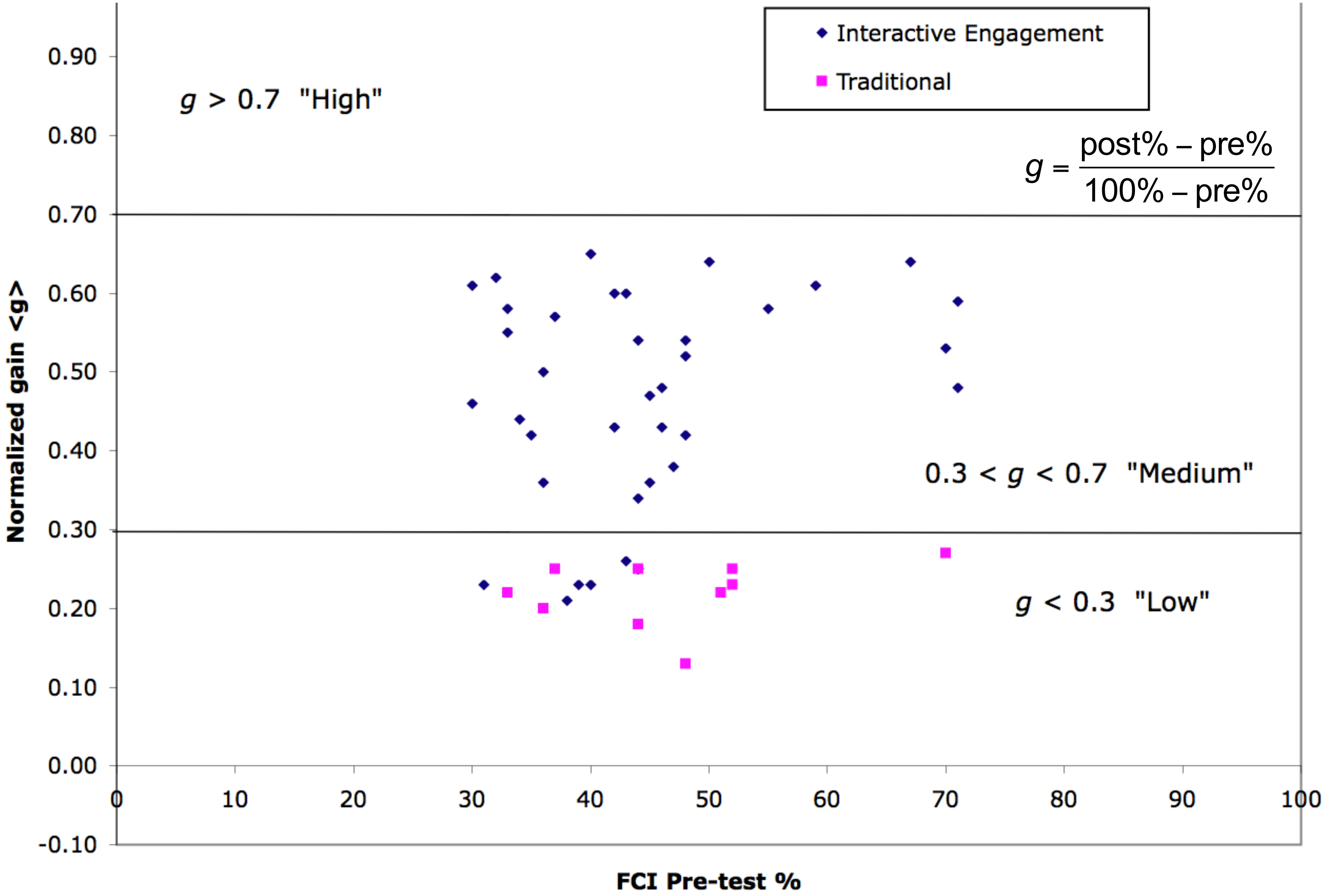
What you can do to help them:

- DO NOT START LECTURING AGAIN!!!
- Just say yes.
- Tell them they are right.
- Ask them to read you the question out loud.
- Diagnose their learning difficulty with a series of 50/50 questions.
- Highlight or provide a helpful/critical piece of information.
- Re-state the question in a conceptually modified/new way.
- Re- frame the scenario (using a illustrative gesture, analogy or metaphor)
- Take them back to a previous question to check their reasoning and help them get on the right track.

Are you really teaching if no one is learning?

And How would you know?

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



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

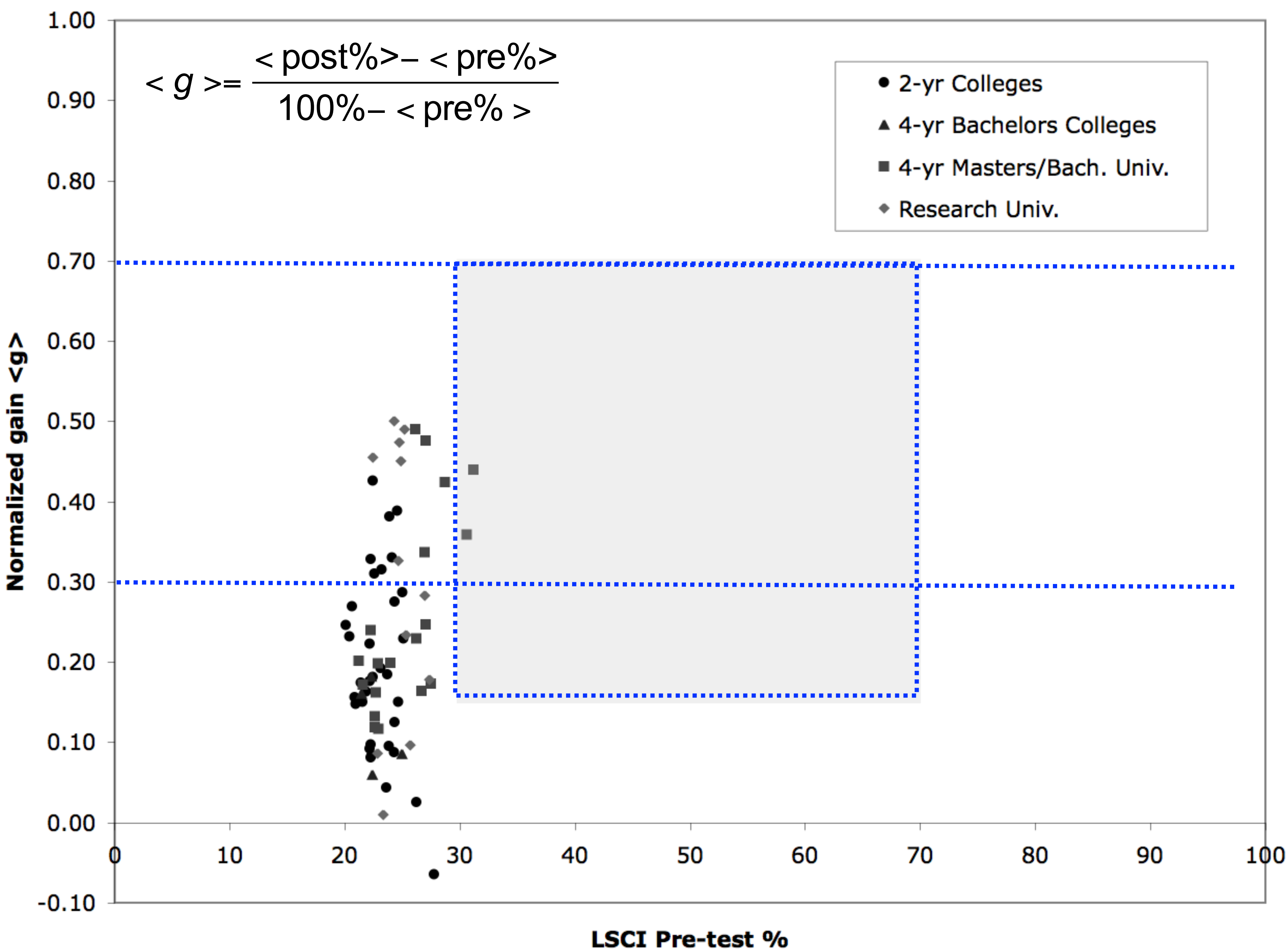
CAE National Study

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

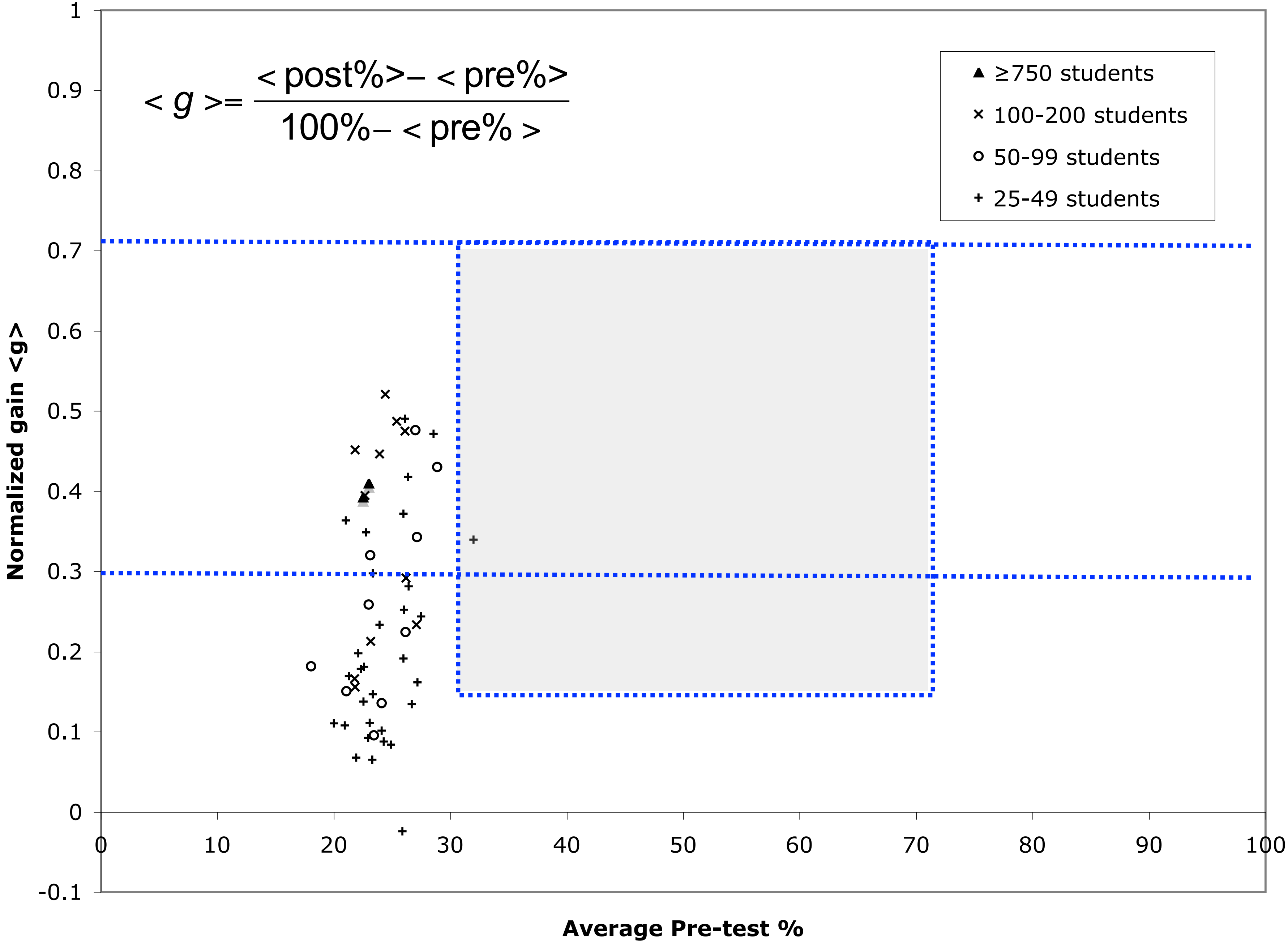
This was a truly national study

Center for Astronomy Education

» Dedicated to the professional development of introductory astronomy instructors



$$< g >= \frac{< post\% > - < pre\% >}{100\% - < pre\% >}$$
2-yr Colleges
4-yr Bachelors Colleges
4-yr Masters/Bach. Univ.
Research Univ.
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

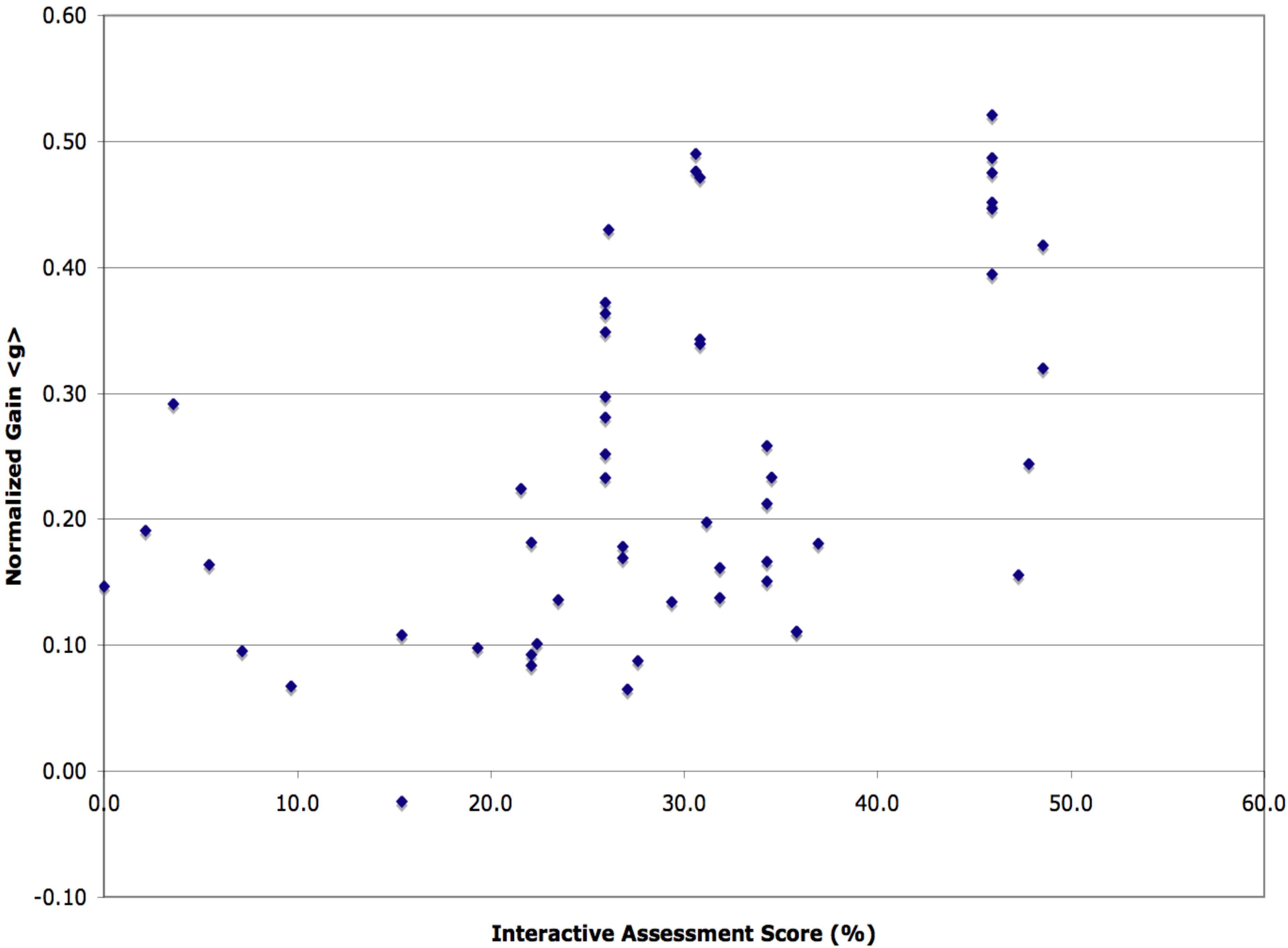


$$\langle g \rangle = \frac{\langle post\% \rangle - \langle pre\% \rangle}{100\% - \langle pre\% \rangle}$$
≥750 students
100-200 students
50-99 students
25-49 students
Normalized gain <g>
Average Pre-test %
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-0.1
0
10
20
30
40
50
60
70
80
90
100

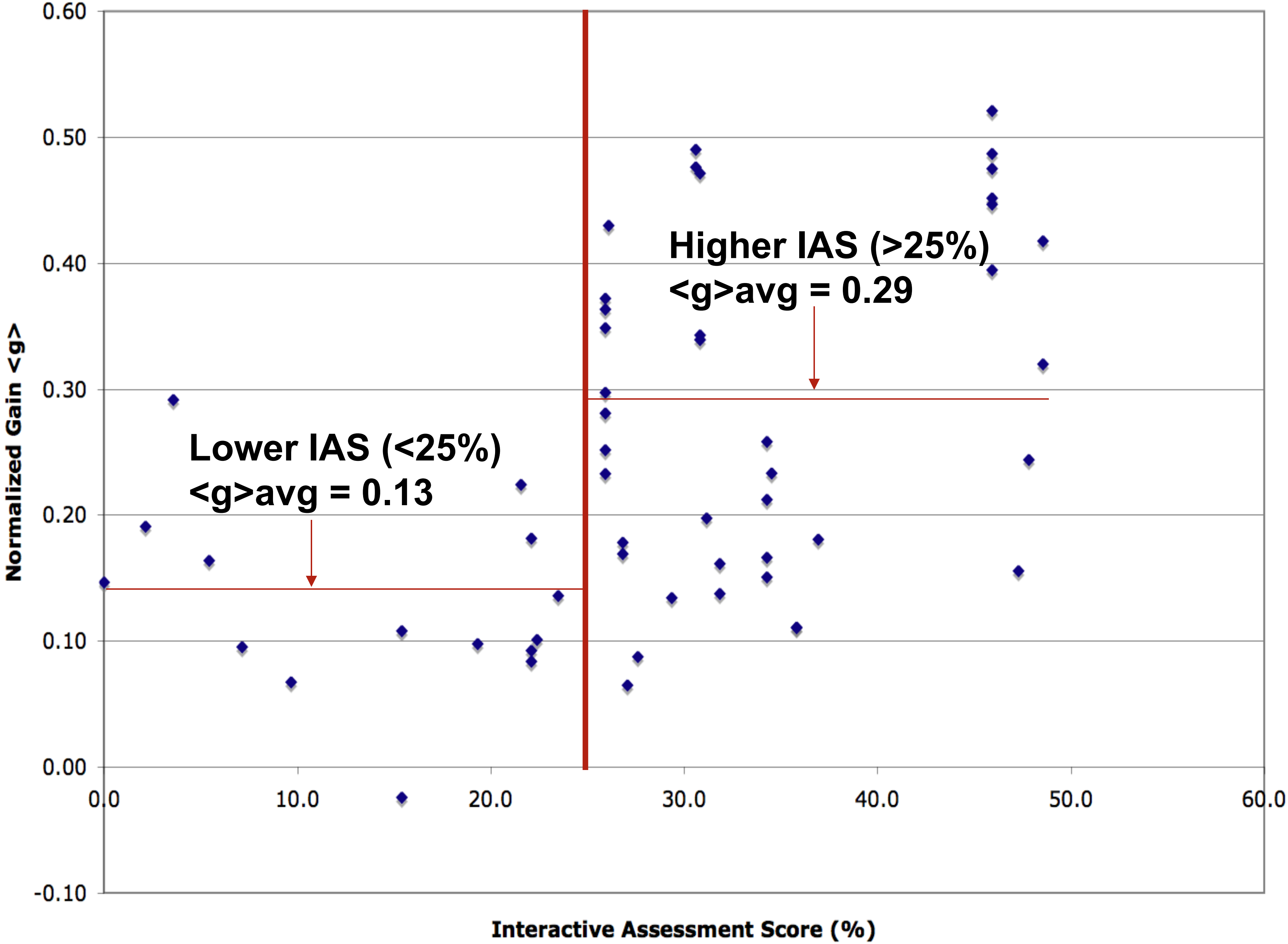
Instructor Surveys

- To assess the level of interactivity in each classroom, we asked each instructor to fill out a survey detailing how they spent their class time

- This survey was used to construct an "Interactivity Assessment Score" (IAS) based on what percentage of total class time is used for interactive activities



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 (%)



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

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

	Normalized Gain							
	1		2		3		4	
Independent Variable	Coefficients (standard error)	Standardized Coefficients	Coefficients (standard error)	Standardized Coefficients	Coefficients (standard error)	Standardized Coefficients	Coefficients (standard error)	Standardized Coefficients
Constant	-0.070 (0.059)		-0.235** (0.060)		-0.266* (0.120)		-0.208** (0.061)	
Male	0.093** (0.016)	0.183**	0.087** (0.015)	0.170**	0.085* (0.038)	0.167*	0.087** (0.015)	0.171**
White	0.019 (0.020)	0.032	0.012 (0.020)	0.020	0.033 (0.055)	0.055	0.013 (0.019)	0.021
Native English speaker	0.019 (0.029)	0.022	0.013 (0.028)	0.015	-0.049 (0.080)	-0.057	0.011 (0.028)	0.013
Father with Bachelor's degree or higher	0.008 (0.016)	0.015	0.004 (0.016)	0.008	0.004 (0.016)	0.008	0.005 (0.016)	0.009
Natural log of Family Income	0.002 (0.010)	0.008	0.002 (0.009)	0.008	0.002 (0.009)	0.006	0.003 (0.009)	0.008
Class year	0.018* (0.008)	0.071*	0.024** (0.008)	0.092**	0.024** (0.008)	0.093**	0.024** (0.008)	0.093**
College GPA	0.036** (0.010)	0.106**	0.037** (0.010)	0.109**	0.067** (0.026)	0.197**	0.036** (0.010)	0.106**
Arts, Humanities, or Social Science major	0.101** (0.018)	0.176**	0.104** (0.017)	0.181**	0.010 (0.042)	0.018	0.023 (0.041)	0.040
Last math class taken	0.031** (0.005)	0.214**	0.034** (0.005)	0.230**	0.040** -0.011	0.274**	0.034** (0.005)	0.229**
Number of previous physical science course	0.024** (0.006)	0.120**	0.024** (0.006)	0.120**	0.021 (0.015)	0.105	0.023** (0.006)	0.119**
Previous Astrophysics course	-0.029 (0.022)	-0.039	-0.028 (0.022)	-0.039	-0.031 (0.022)	-0.042	-0.030 (0.022)	-0.041
Pretest Percent Correct	-0.005** (0.001)	-0.224**	-0.005** (0.001)	-0.213**	-0.005** (0.001)	-0.213**	-0.005** (0.001)	-0.212**
Interactivity Score			0.0051** (0.0006)	0.258**	0.0062 (0.0037)	0.314	0.0043** (0.0007)	0.217**
Cross term: Interactivity score X Arts, Humanities, Soc Sci Major					0.0032* (0.0013)	0.183*	0.0027* (0.0013)	0.158*
Cross term: Interactivity score X Male					0.0001 (0.0012)	0.004		
Cross term: Interactivity score X White					-0.0006 (0.0018)	-0.044		
Cross term: Interactivity score X Native English speaker					0.0022 (0.0027)	0.129		
Cross term: Interactivity score X College GPA					-0.0010 (0.0008)	-0.182		
Cross term: Interactivity score X Last math class taken					-0.0002 (0.0004)	-0.057		
Cross term: Interactivity score X Number of previous physical science courses					0.0001 (0.0005)	0.016		
F Value	*18.2***		*24.3***		*16.2***		*23.0***	
N	*910*		*910*		*910*		*910*	
Adjusted R-Square	*0.185*		*0.250*		*0.250*		*0.253*	

***p < .05**
****p < .01**

The take home message Part I:

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.

The take home message Part II

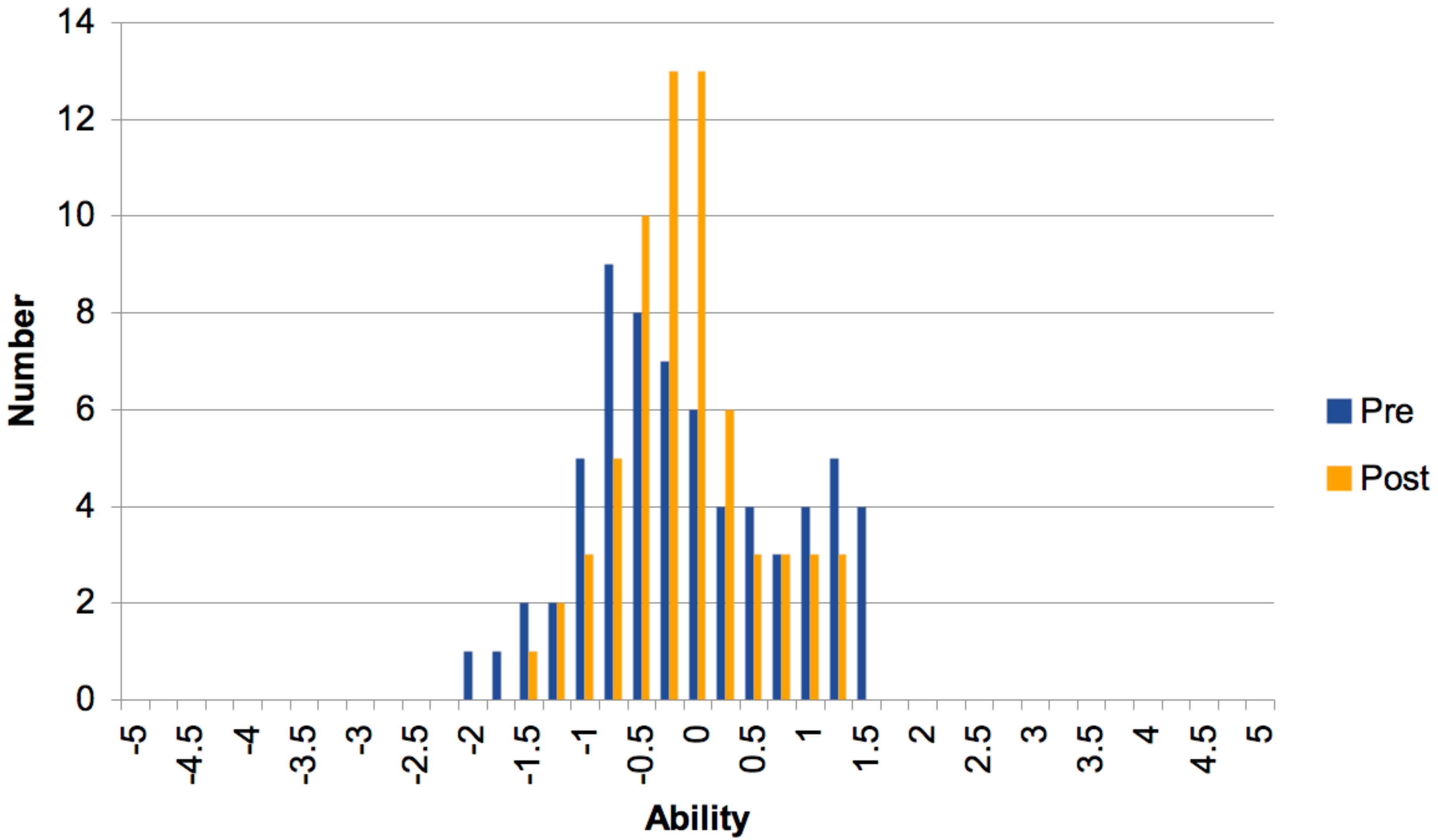
Implementation is the most important factor to success in student learning.

More work on professional development of faculty is needed if we are to see wide spread adoption and proper implementation of research-validated instructional strategies.

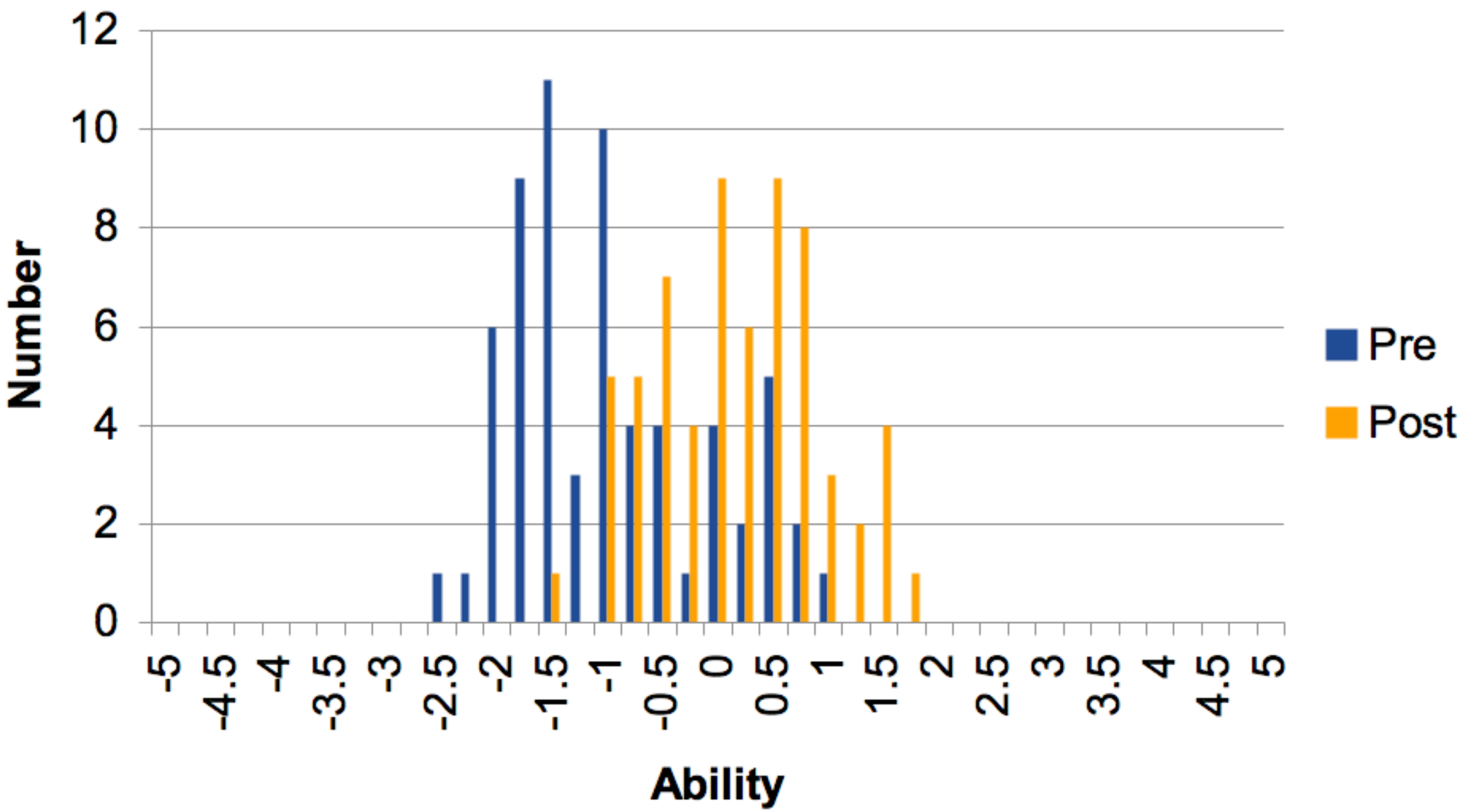
Item Response Theory (IRT)

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

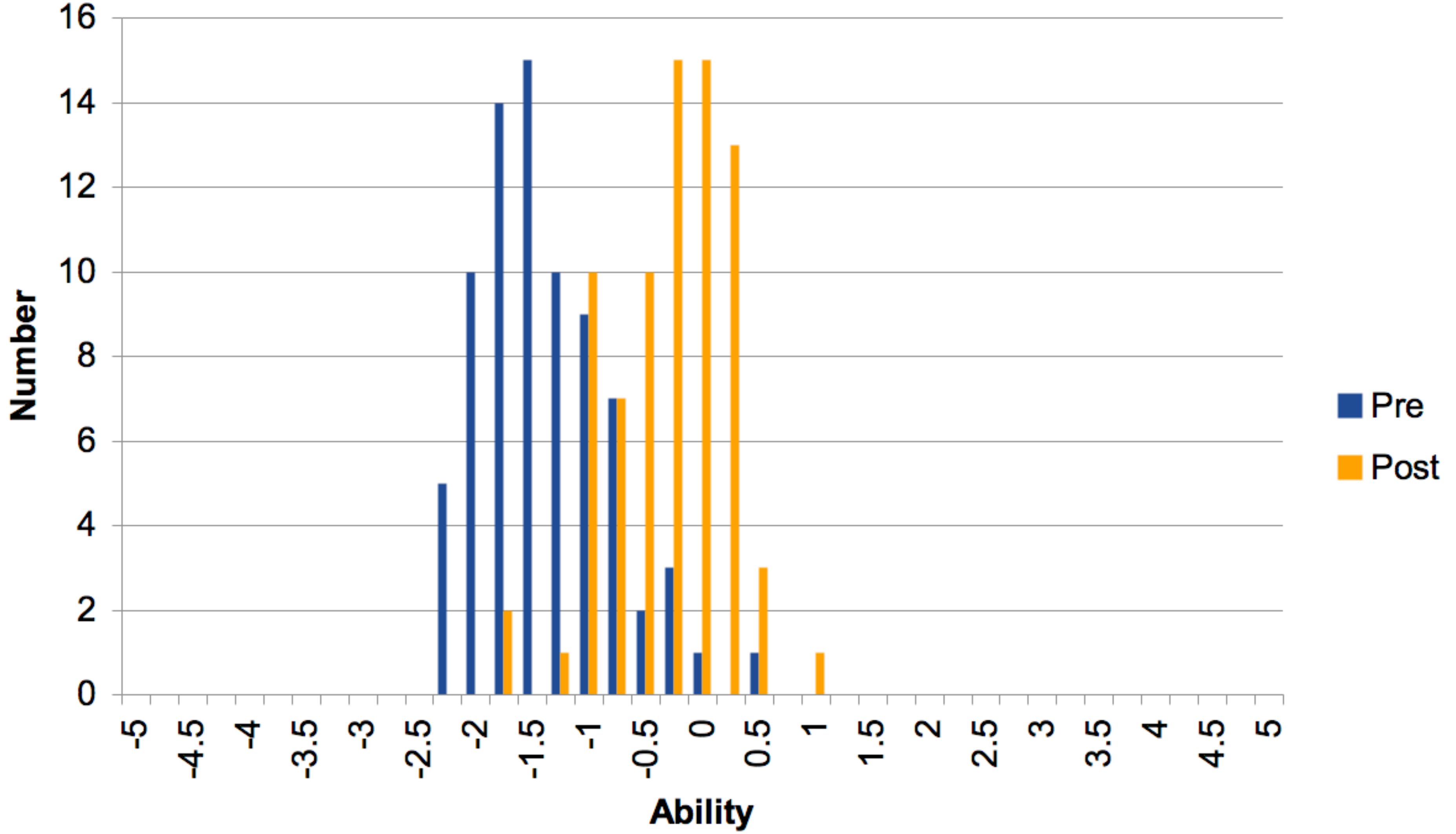
Single Course Ability Histogram



Single Course Ability Histogram

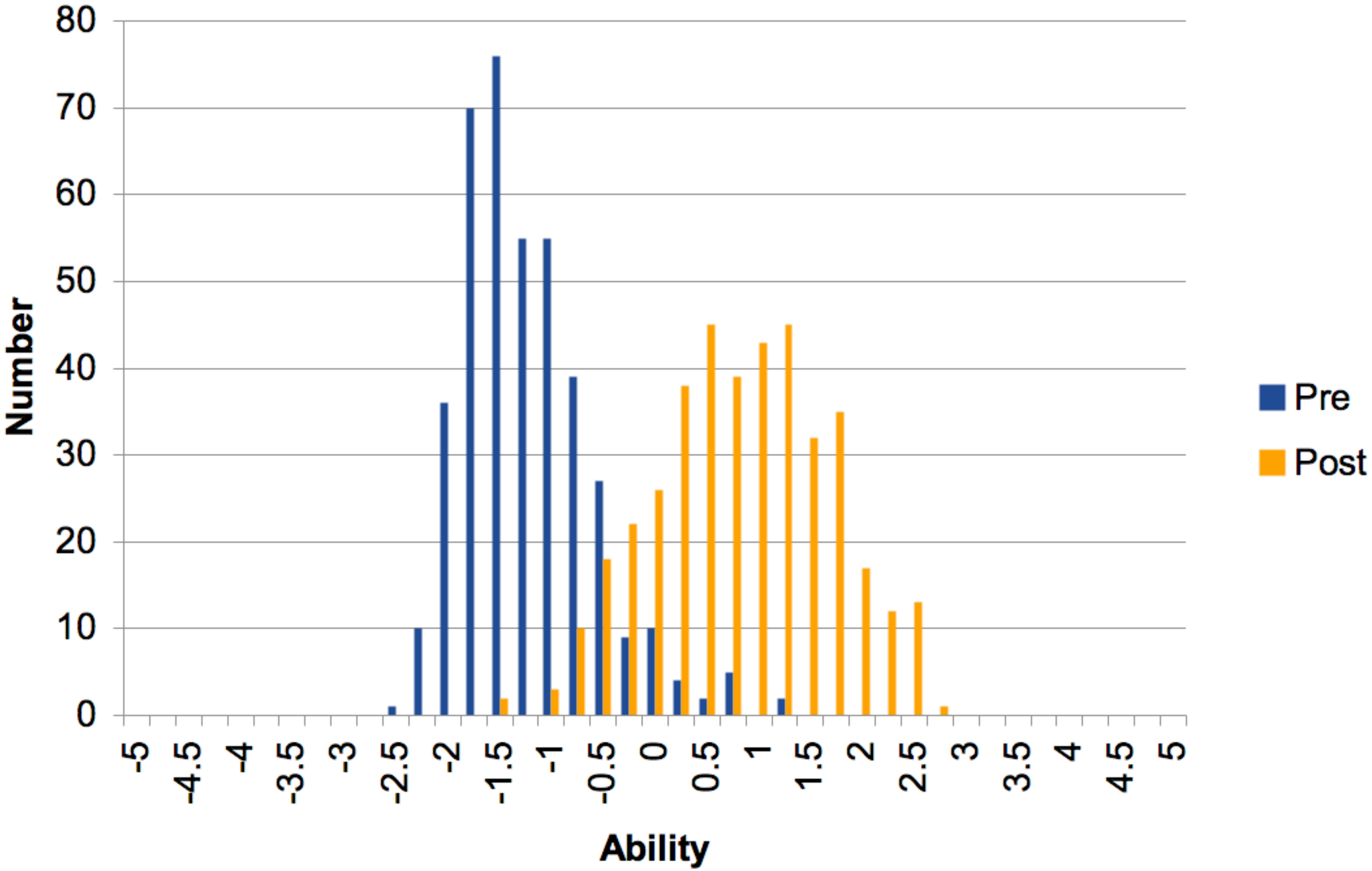


Single Course Ability Histogram



Ambassadors – of science in our society, our nations future leaders

Mega Course Ability Histogram



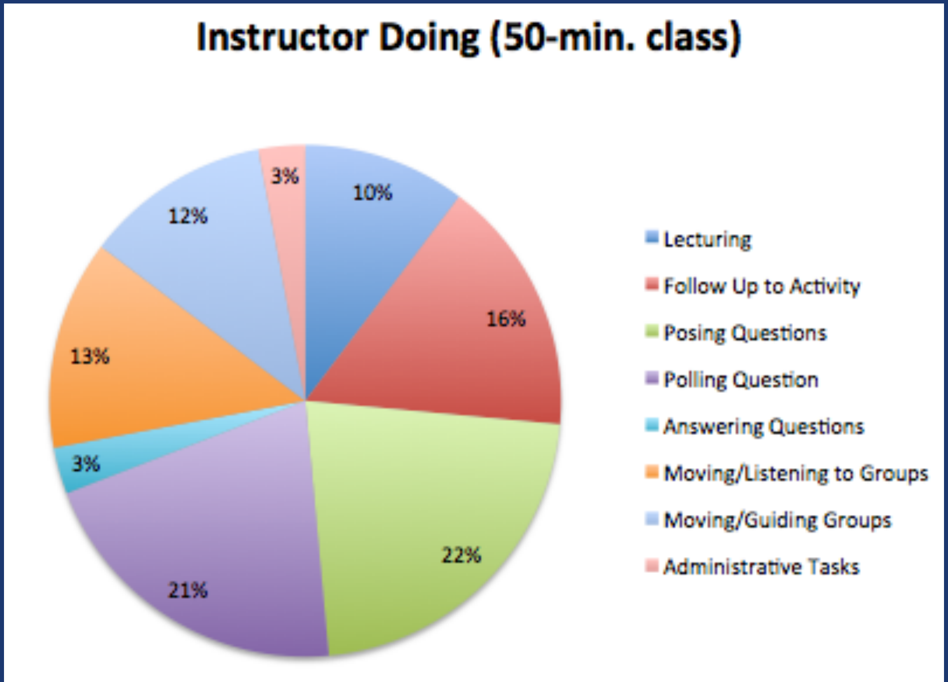
Reformed Class

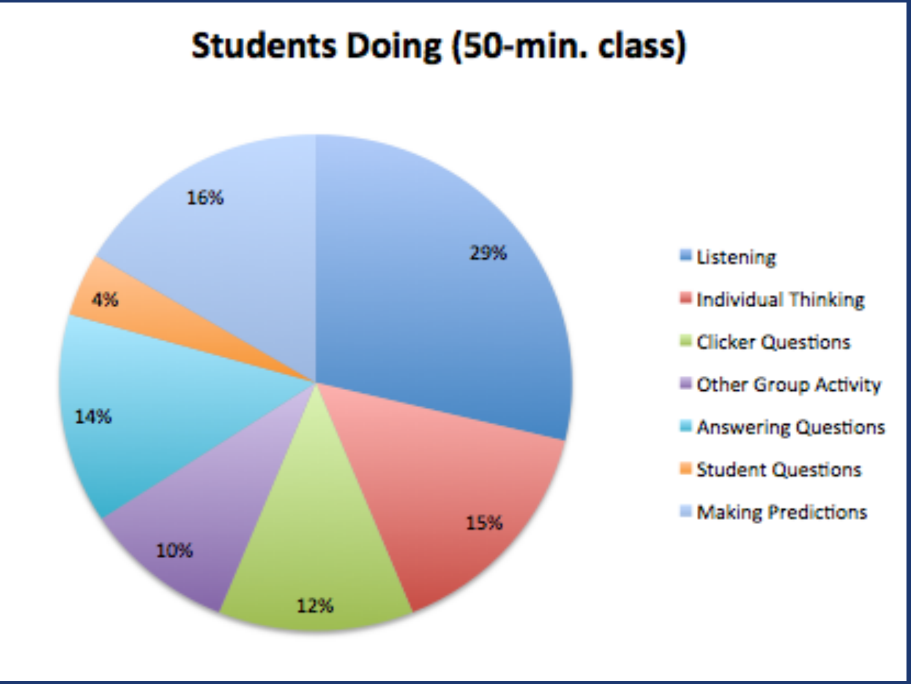
- Two 50 minute lectures per week
  - Focused on introducing concepts using active engagement instructional strategies and on interactive, collaborative problem solving
  - Minimal derivations of equations
- Each student also attends one of ten 50 minute recitation sections per week
  - Led by graduate TA with assistance from undergraduate peer instructors
  - Students work on collaborative tutorials, which promote reasoning abilities and problem solving skills
- Instructor experienced in astronomy and physics education research, but teaching PHYS 141 for the first time

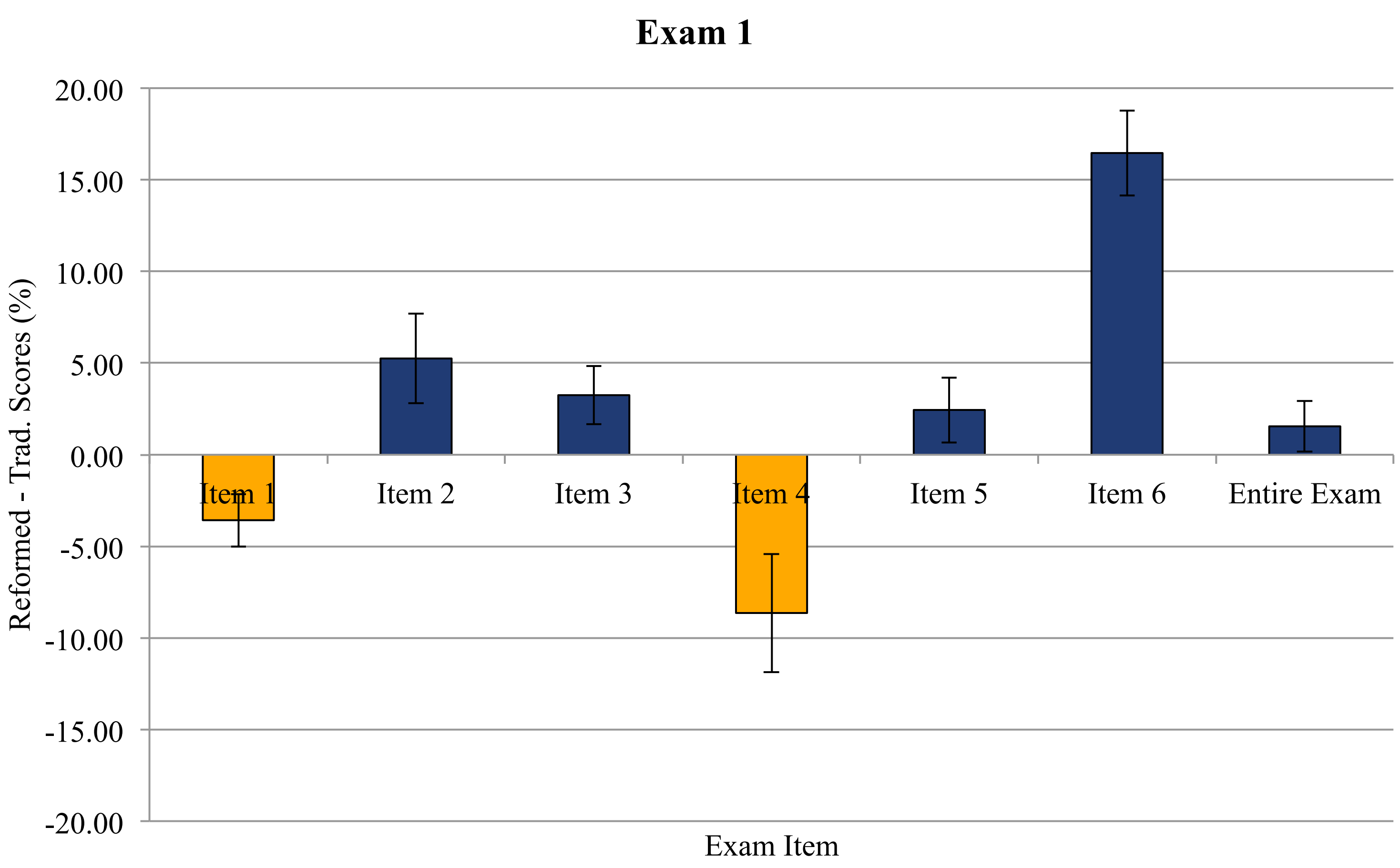
Traditional Class

- Three 50 minute lectures per week
  - Focused on introducing concepts and on instructor-led modeling of problem solving
  - Many derivations of equations
- Instructor experienced in teaching PHYS 141 and widely regarded by faculty and students as an excellent lecturer

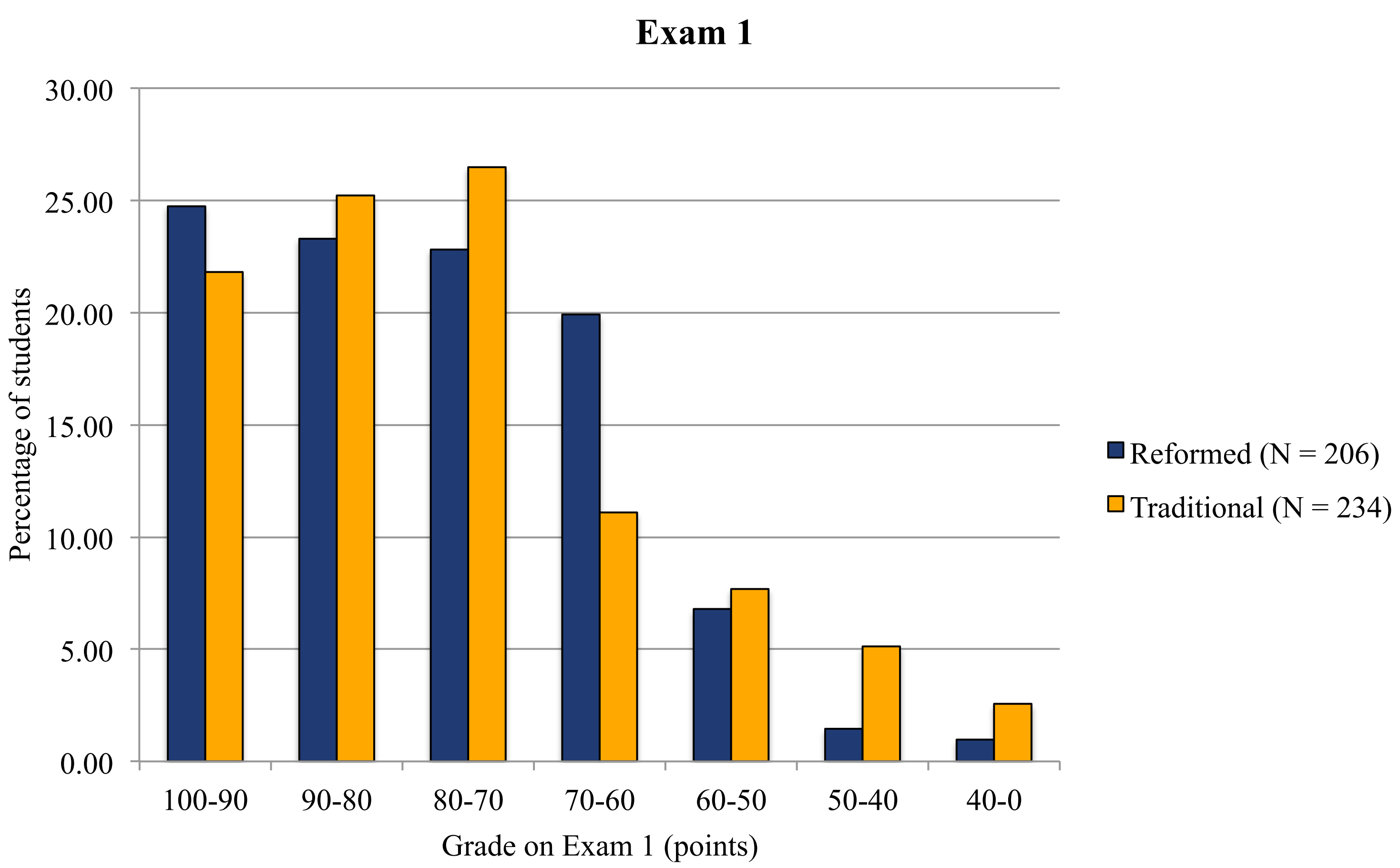
COPUS data from UA Calc-Physics Course

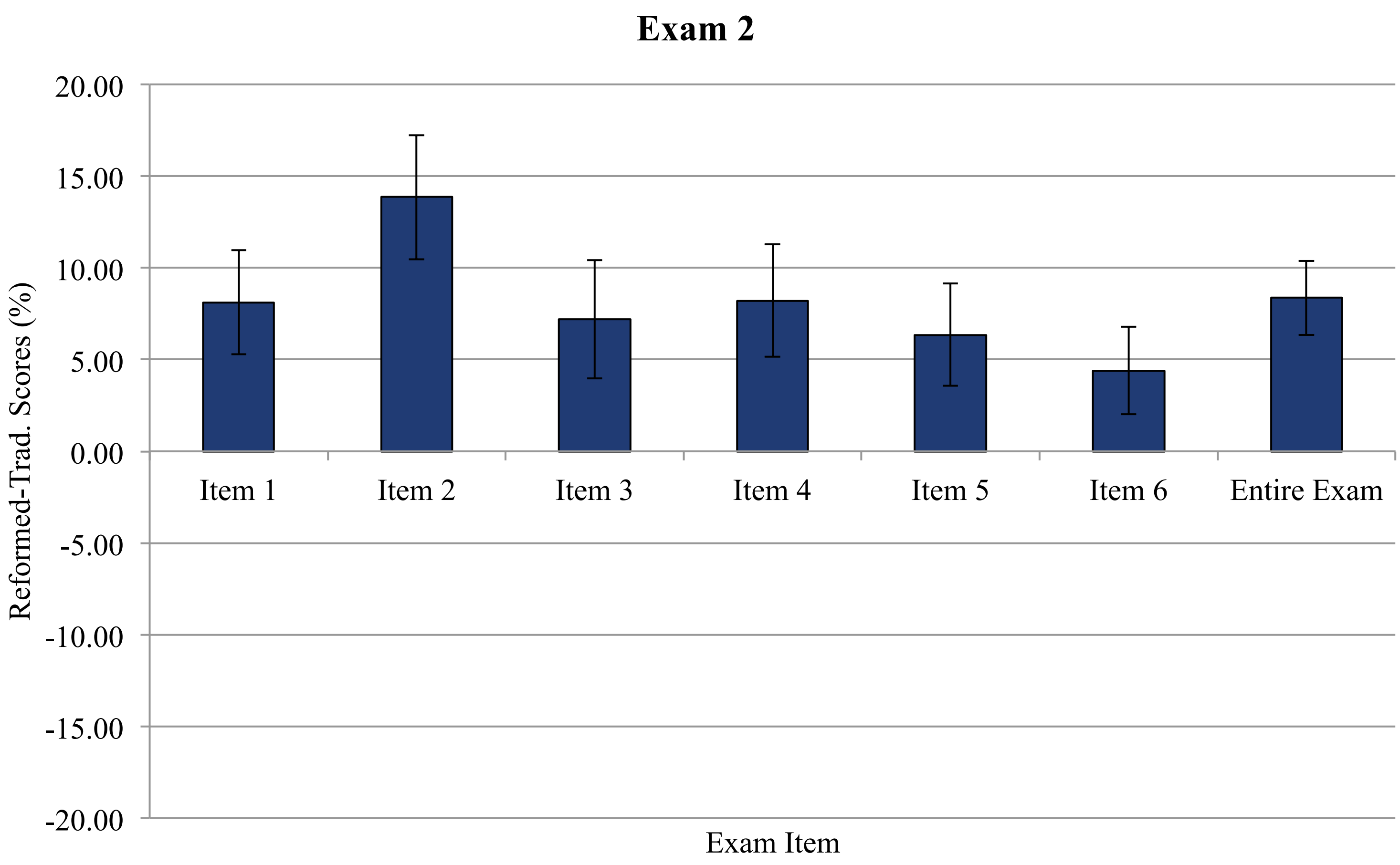


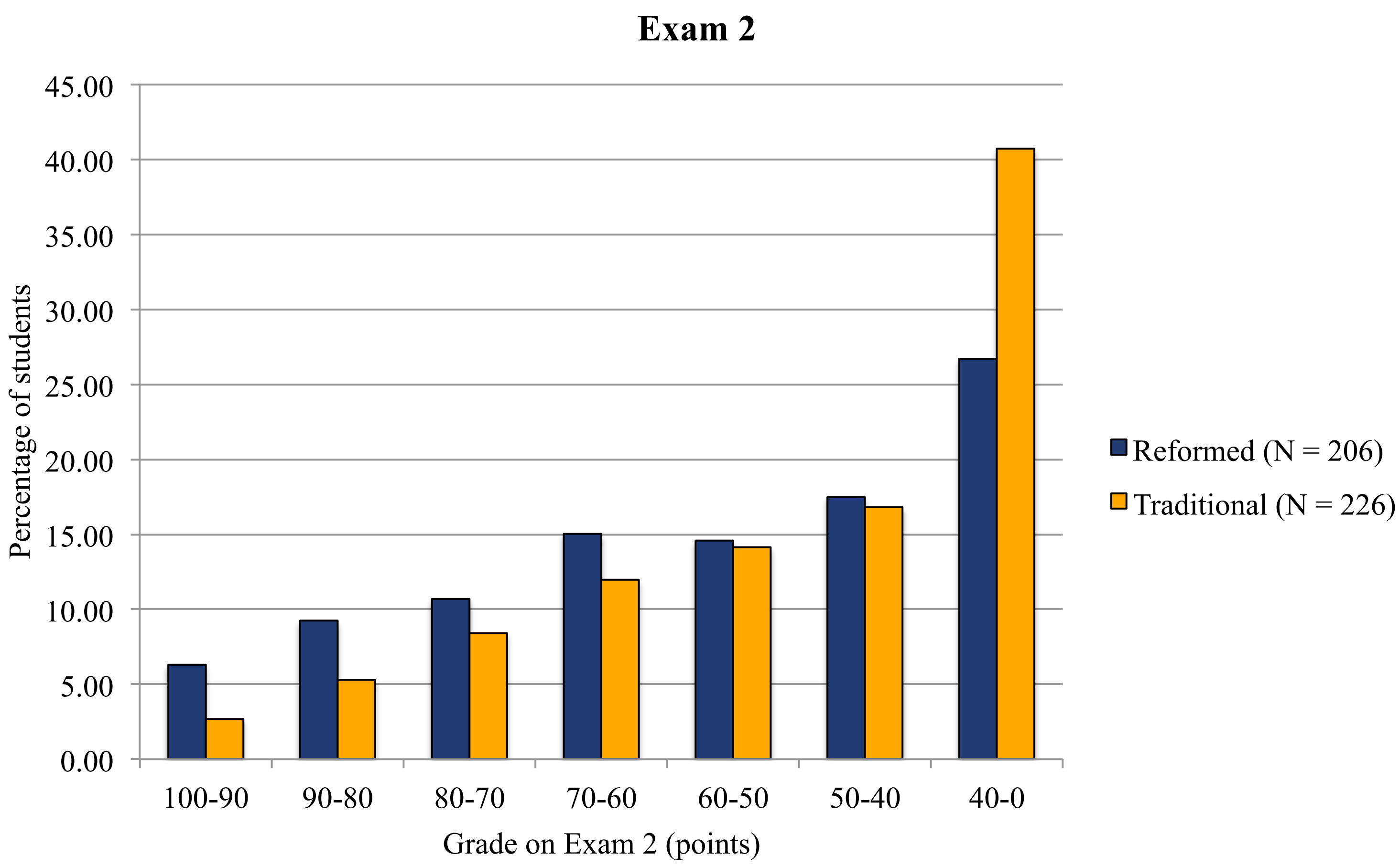


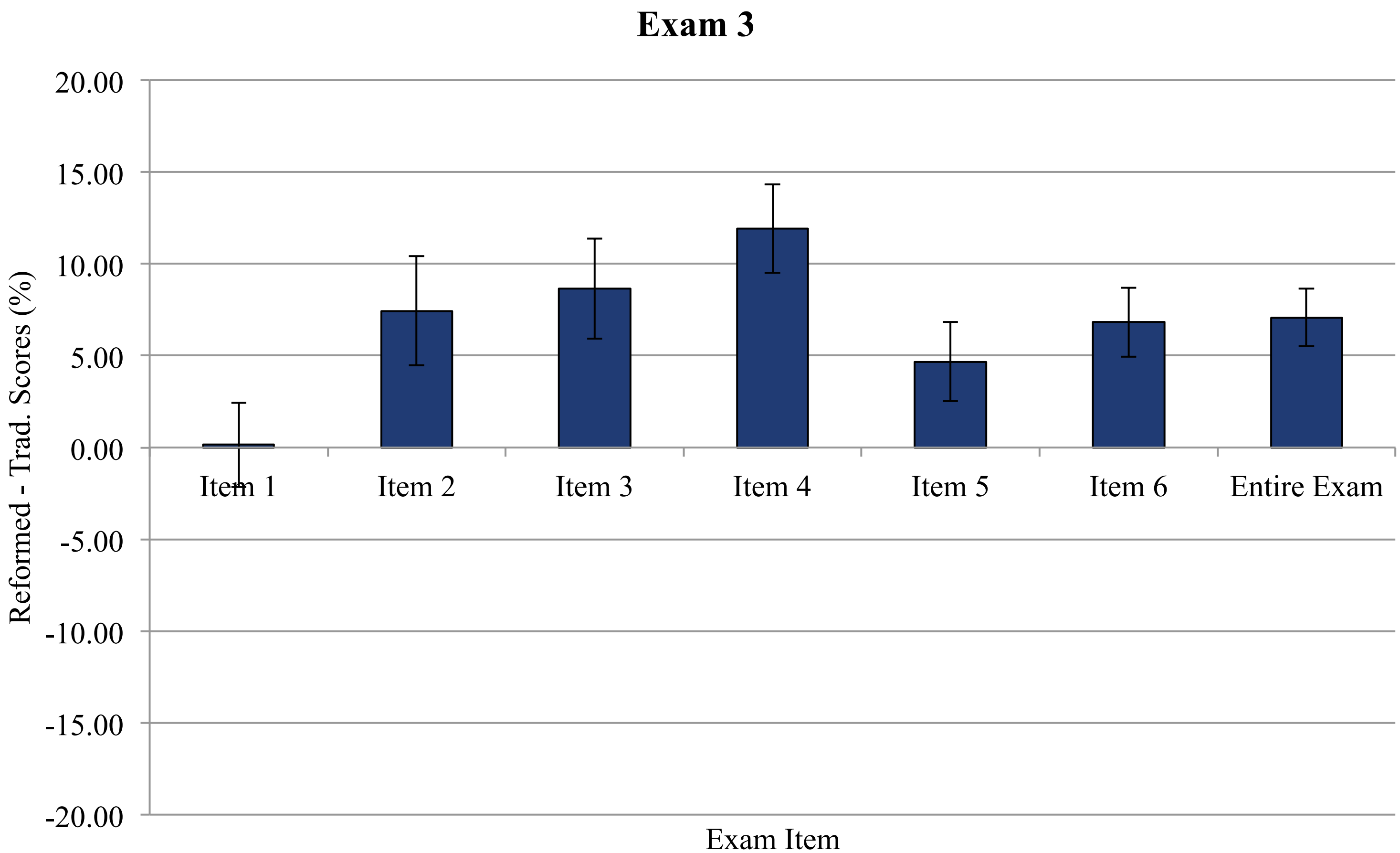


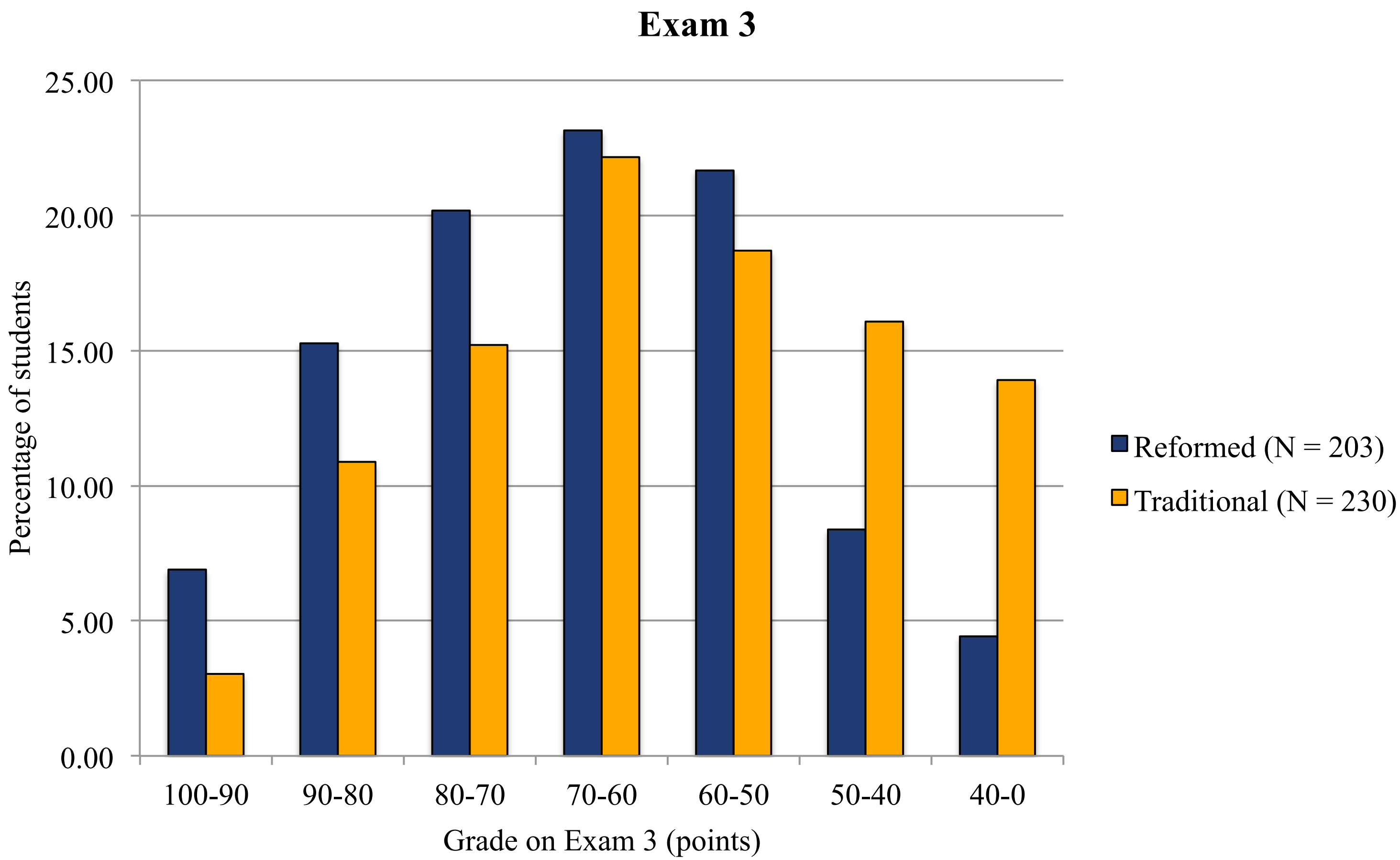
Exam 1
20.00
15.00
10.00
5.00
0.00
-5.00
-10.00
-15.00
-20.00
Reformed - Trad. Scores (%)
Item 1
Item 2
Item 3
Item 4
Item 5
Item 6
Entire Exam
Exam Item

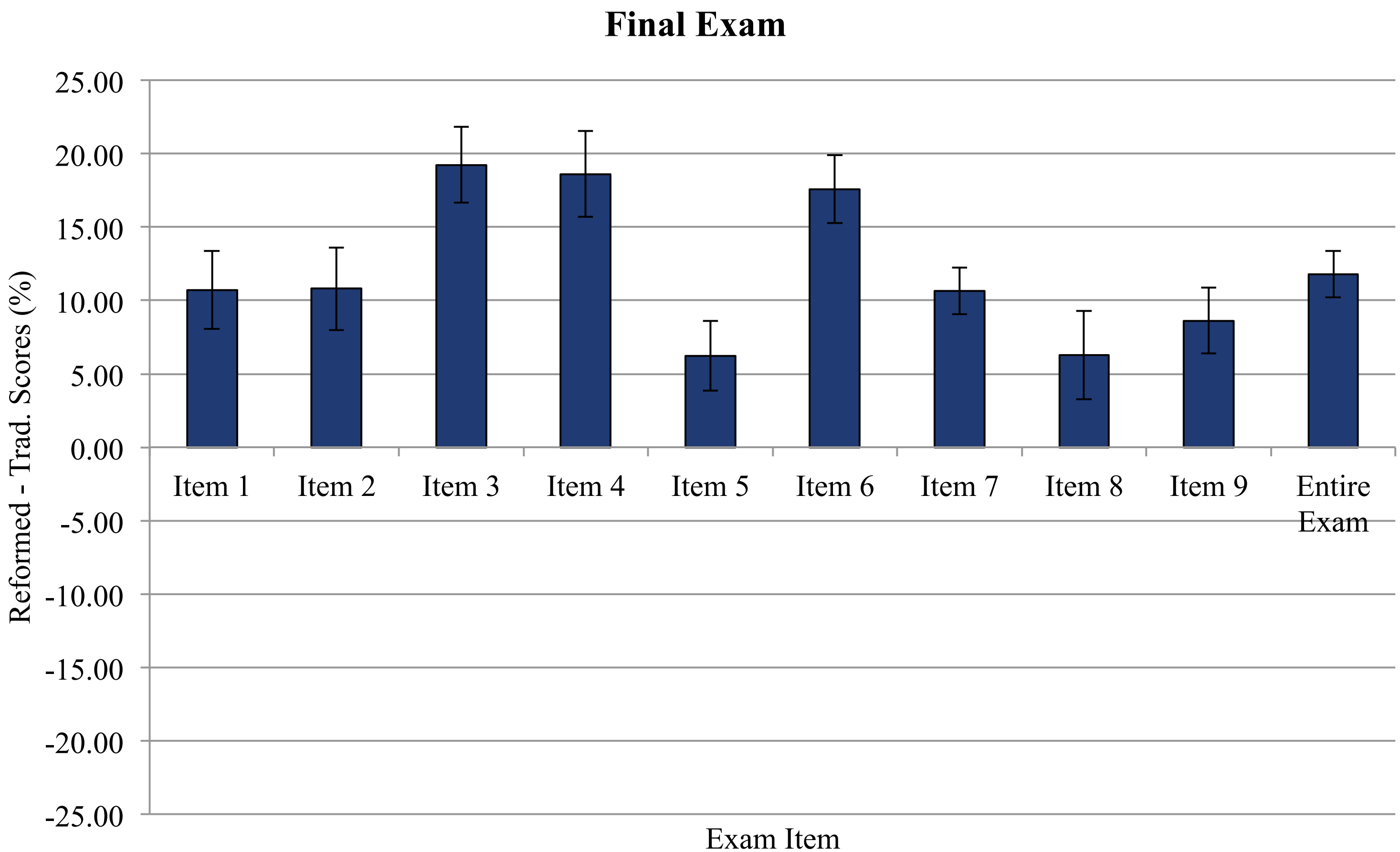

Exam 1
30.00
25.00
20.00
15.00
10.00
5.00
0.00
Percentage of students
100-90
90-80
80-70
70-60
60-50
50-40
40-0
Grade on Exam 1 (points)
Reformed (N = 206)
Traditional (N = 234)

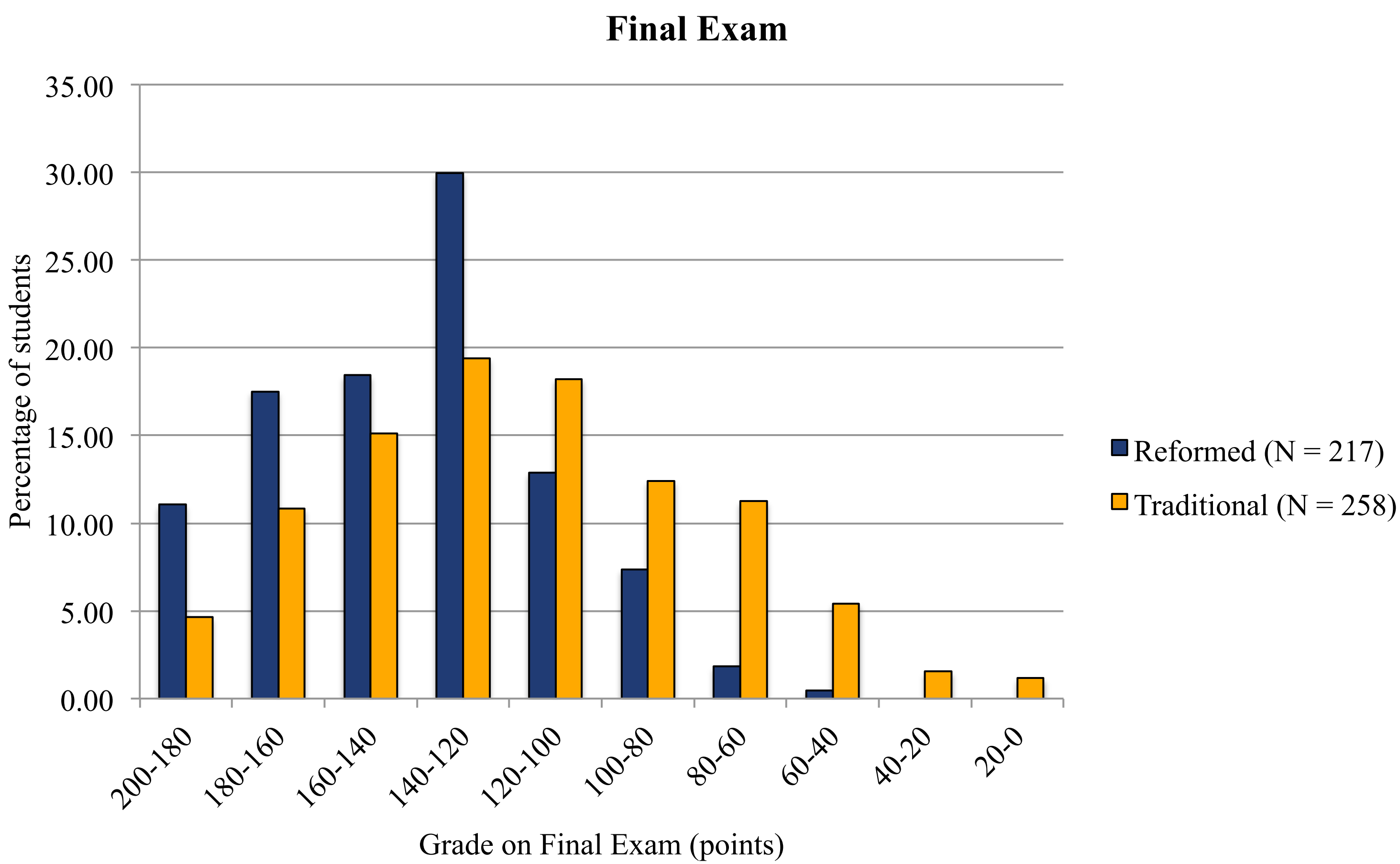

Exam 2
20.00
15.00
10.00
5.00
0.00
-5.00
-10.00
-15.00
-20.00
Reformed-Trad. Scores (%)
Item 1
Item 2
Item 3
Item 4
Item 5
Item 6
Entire Exam
Exam Item


Exam 2
45.00
40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
Percentage of students
100-90
90-80
80-70
70-60
60-50
50-40
40-0
Grade on Exam 2 (points)
Reformed (N = 206)
Traditional (N = 226)


Exam 3
Reformed - Trad. Scores (%)
20.00
15.00
10.00
5.00
0.00
-5.00
-10.00
-15.00
-20.00
Item 1
Item 2
Item 3
Item 4
Item 5
Item 6
Entire Exam
Exam Item


Exam 3
25.00
20.00
15.00
10.00
5.00
0.00
Percentage of students
100-90
90-80
80-70
70-60
60-50
50-40
40-0
Grade on Exam 3 (points)
Reformed (N = 203)
Traditional (N = 230)


Final Exam
25.00
20.00
15.00
10.00
5.00
0.00
-5.00
-10.00
-15.00
-20.00
-25.00
Reformed - Trad. Scores (%)
Item 1
Item 2
Item 3
Item 4
Item 5
Item 6
Item 7
Item 8
Item 9
Entire Exam
Exam Item


Final Exam
Percentage of students
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
200-180
180-160
160-140
140-120
120-100
100-80
80-60
60-40
40-20
20-0
Grade on Final Exam (points)
Reformed (N = 217)
Traditional (N = 258)