



# **Common Concerns about the Force Concept Inventory**

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# Introduction

## Why do we care about the FCI?

- **Quality Assurance**

**Quick and Easy to Administer**

**Robust**

**Responds to Changes in Instruction**

- **Widely Used**



## U of MN

### Introductory Calc-Based Physics

- **Traditional format: 3 hours of lecture, one 2-hour lab, one 1-hour recitation each week**
- **Goal of course is to learn physic through problem-solving;**
- **Non-traditional pedagogy: Cooperative Group Problem-Solving**

### FCI Testing

- **Pre Test**  $\supset$  **first week of labs (ungraded)**
- **Post Test**  $\supset$  **as part of final exam (graded)**  
**or**  
**last week of labs (ungraded)**



# Common Concerns about the FCI

Question	Response
<b>1. Can FCI pre test be used as a diagnostic test?</b>	<b>No</b>
<b>2. Does the FCI post test correlate with desired course outcomes (problem solving grades)?</b>	<b>Somewhat</b> ( $r \sim 0.51$ )
<b>3. Do students take the FCI seriously when it is not graded?</b>	<b>Yes</b>



# Common Concerns about the FCI

Question	Response
<b>4. Does giving the FCI as a pre test bias post test results?</b>	<b>No</b>
<b>5. Who gains?</b>	<b>All Students</b>
<b>6. Are there gender differences in FCI scores?</b>	<b>Yes</b>



## Question #1

**Question: Can FCI pre test be used as a diagnostic test?**

**Method: Look at the correlation between FCI pre test scores and desired course outcome (grades on written problems on the final exam).**



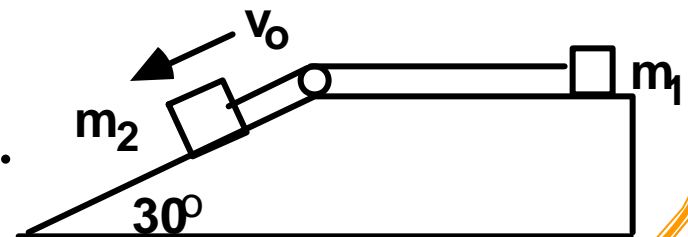
# Typical Final Exam Problems

## Introductory Calculus-Based Physics

1. On the way to work, you drive along a curved section of highway which gets extremely slippery in bad winter weather. You want to know how fast you can drive around the curve without having to rely on the friction between your worn-out tires and the slippery road. You estimate that the banking of that section of the road is about  $5^\circ$  relative to the horizontal and the radius of curvature is 200 m. How fast can you drive safely?
2. In the diagram shown below, block 1 of mass 1.5 kg and block 2 of mass 4 kg are connected by a light taut rope that passes over a frictionless pulley. Block 2 is just over the edge of the ramp inclined at an angle of  $30^\circ$ , and the blocks have a coefficient of sliding friction of 0.21 with the surface. At time  $t = 0$ , the system is given an initial speed of 11 m/s that starts block 2 down the ramp.

(a) Find the tension in the rope.

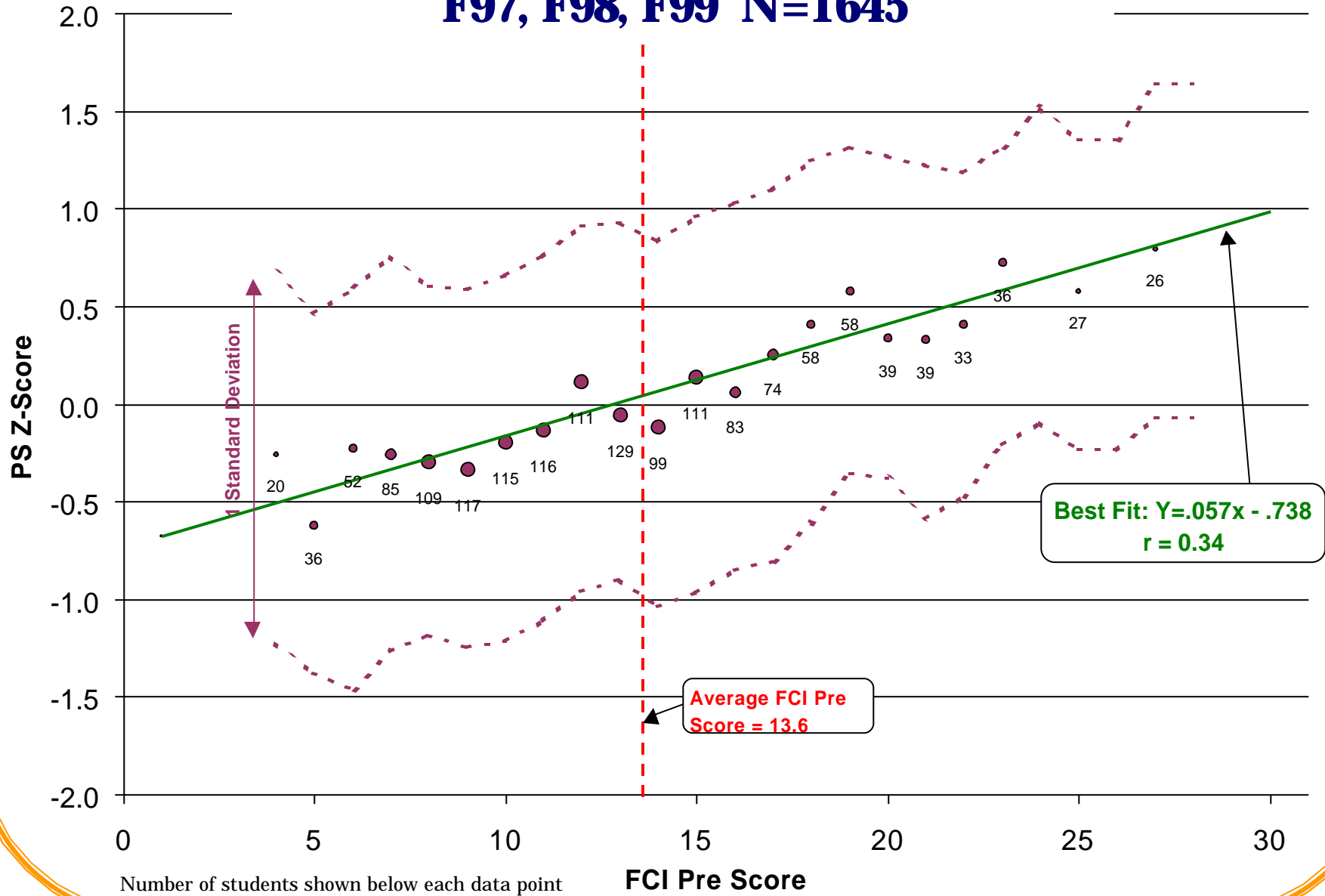
(b) Find the speed of the two masses at  $t = 2$  s.





# FCI Pre vs. PS Grade

F97, F98, F99 N=1645







## Question #2

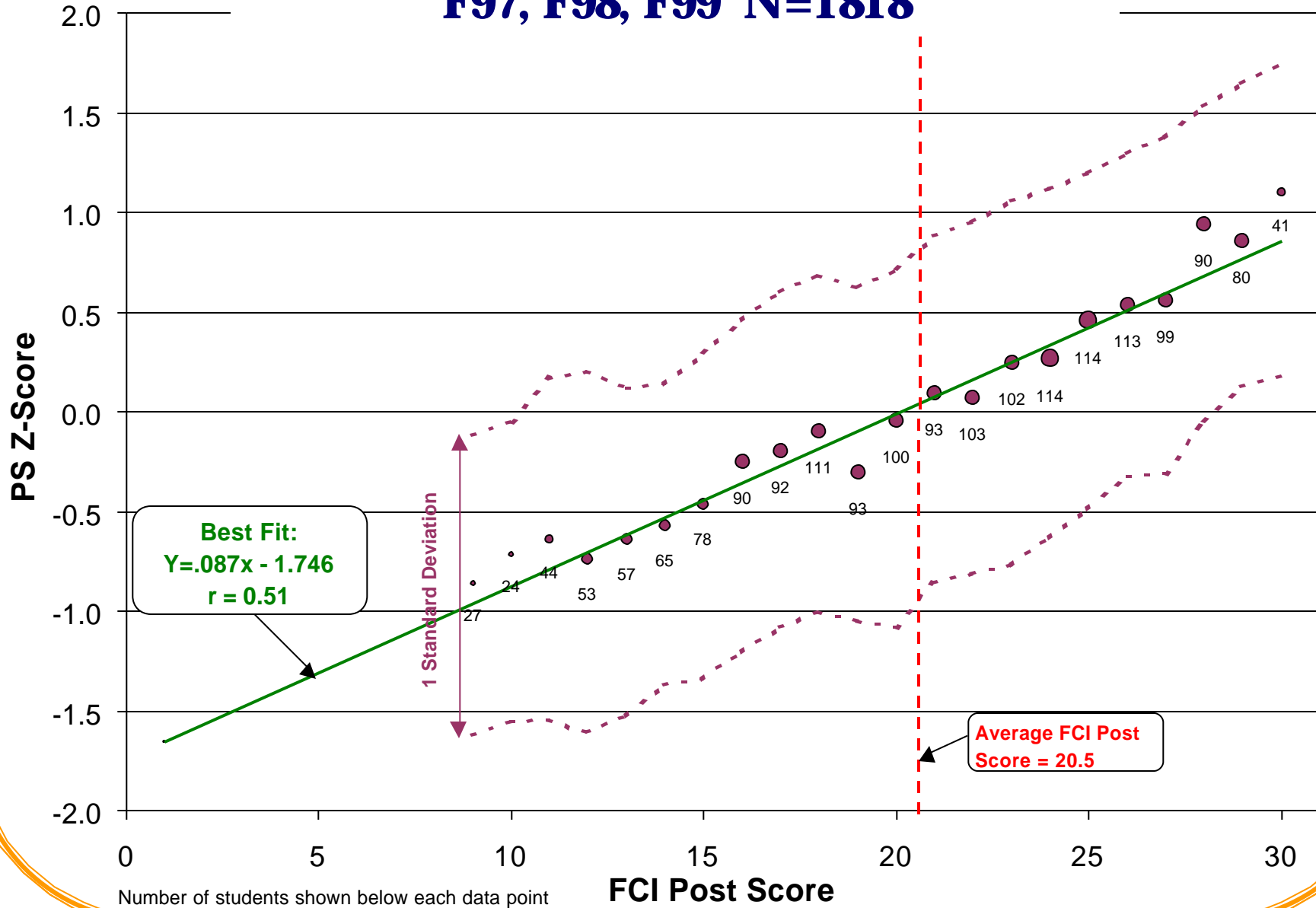
**Question: Does the FCI post test correlate with desired course outcomes (problem solving grades)?**

**Method: Look at the correlation between FCI post test scores and desired course outcome (grades on written problems on the final exam).**



# FCI Post vs. PS Grade

F97, F98, F99 N=1818





## Question #3

**Question: Do students take the FCI seriously when it is not graded?**

**Method: Look for differences between ungraded FCI tests and graded FCI tests**

- **Obvious lack of seriousness**
- **Subtle lack of seriousness**



# Obvious Lack of Seriousness

## Lack of Seriousness

## % of Students for Ungraded\*

- |                                      |            |
|--------------------------------------|------------|
| • Refuse to take test                | ~0.5%      |
| • Draws a picture                    | ~0.2%      |
| • Answers all A's, B's, etc.         | none found |
| • Leaves a lot of blanks (6 or more) | ~1.5%      |
| • Other systematic patterns          | ~0.2%      |

\*Based on data from N=1818 introductory Calculus-Based physics students at the University of Minnesota from 1997-1999.



# Subtle Lack of Seriousness

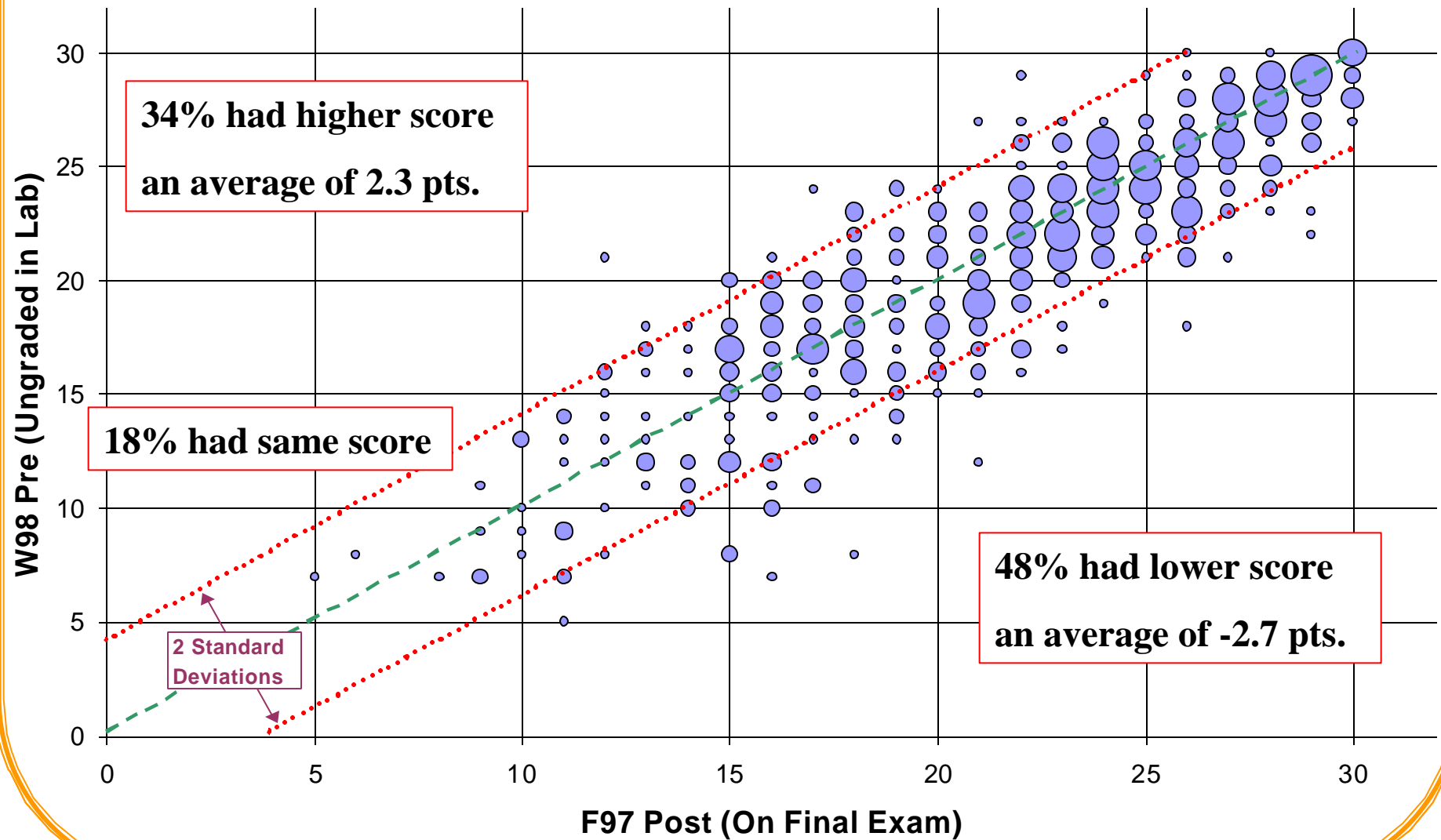
	FCI Score (N=500)
Fall 1997 (On Final Exam)	71.4%
Winter 1998 (Ungraded in Lab)	69.8%
<b>Difference*</b>	<b>1.6%</b> (~0.5 FCI items)

\*Significant difference on a matched sample t-test



## Test-Retest Comparison

N=500, r=0.88

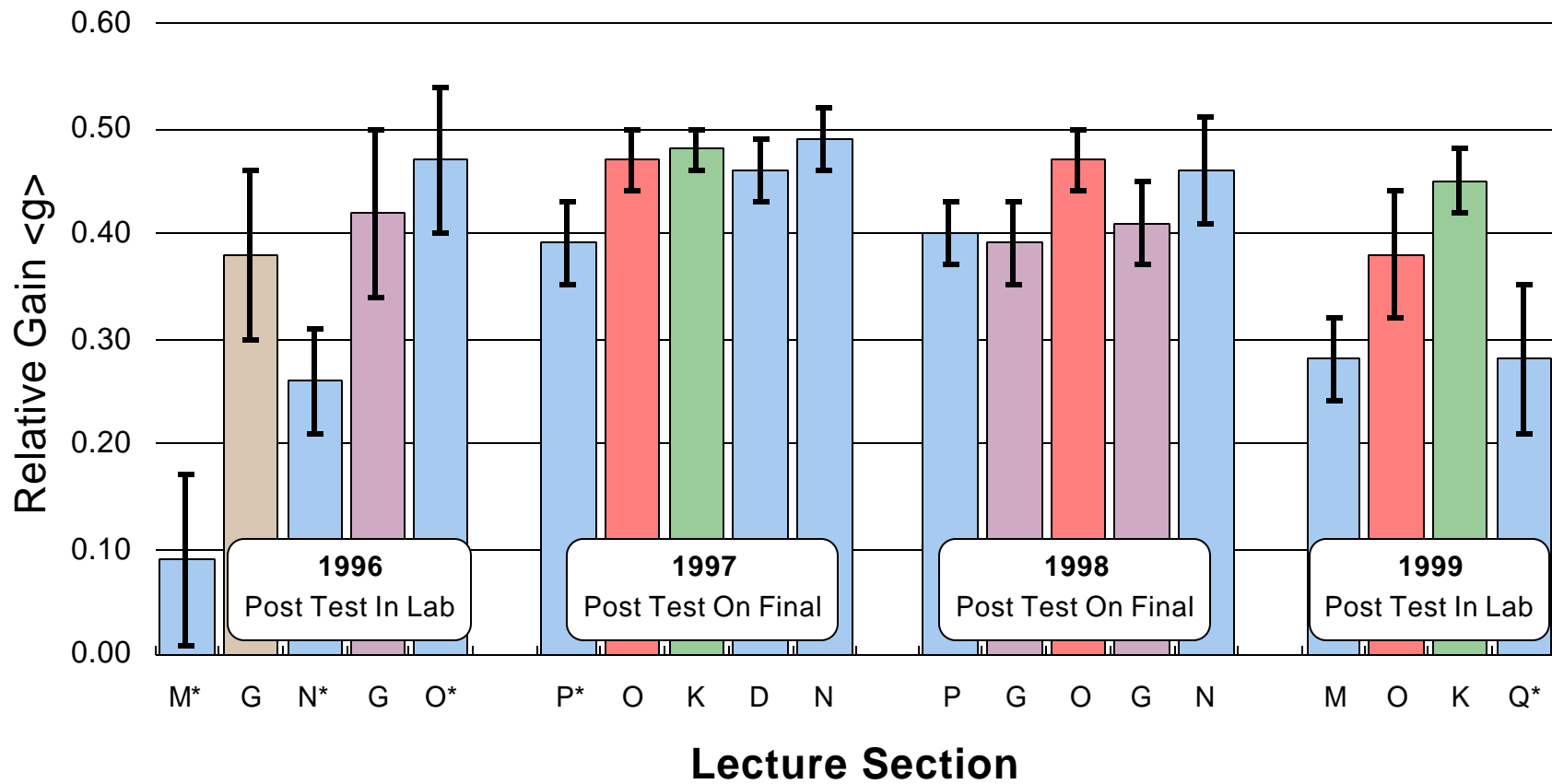




# Seriousness

No significant differences in FCI relative gain by the same professor between years when the post test is graded and when the post test is ungraded.

## FCI Gains University of Minnesota, 1996-1999 Introductory Calculus-Based Physics



I - Standard Error of the Mean

\* - First Time With Course



# Conclusions

**Question**

**Response**

**1. Can FCI pre test be used as a diagnostic test?**

**Correlation between FCI pre test and course outcome (problem solving grades)**

**No**

**( $r \sim 0.34$ )**

**low slope**

**(0.057)**

**2. Does the FCI correlate with desired course outcomes (problem solving grades)?**

**Somewhat**

**( $r \sim 0.51$ )**

**higher slope**

**(0.087)**





# Conclusions

**Question**

**Response**

**3. Do students take the FCI seriously when it is not graded?**

**Yes**

- **Most of the ways students don't take the test seriously are easy to spot (we remove these students from our analysis):**

**Not taking the Test**

**Leaving 6 or more blanks**

- **There is no meaningful difference between FCI scores on a graded test and an ungraded test.**



## **Question #4**

**Question: Does giving the FCI as a pre test bias post test results?**

**Method: Compare post test scores for students who had pre test and students who did not. (Lab groups were 'randomly' assigned to the group that received pre test or the group that did not receive the pre test.)**



# Pre Test vs. No Pre Test

## FCI Post

### Fall 1998

**FCI Pre (N=440) . . . . . 70.5%**

**No FCI Pre (N=161) . . . . . 68.7%**

**No significant difference on a  
pooled variance t-test (P=0.29)**

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### Fall 1999

**FCI Pre (N=355) . . . . . 65.2%**

**No FCI Pre (N=170) . . . . . 64.3%**

**No significant difference on a  
pooled variance t-test (P=0.63)**



## Question #5

**Question: Who gains?**

**Method: Look at the relationship between relative gains on the FCI and pre test scores.**

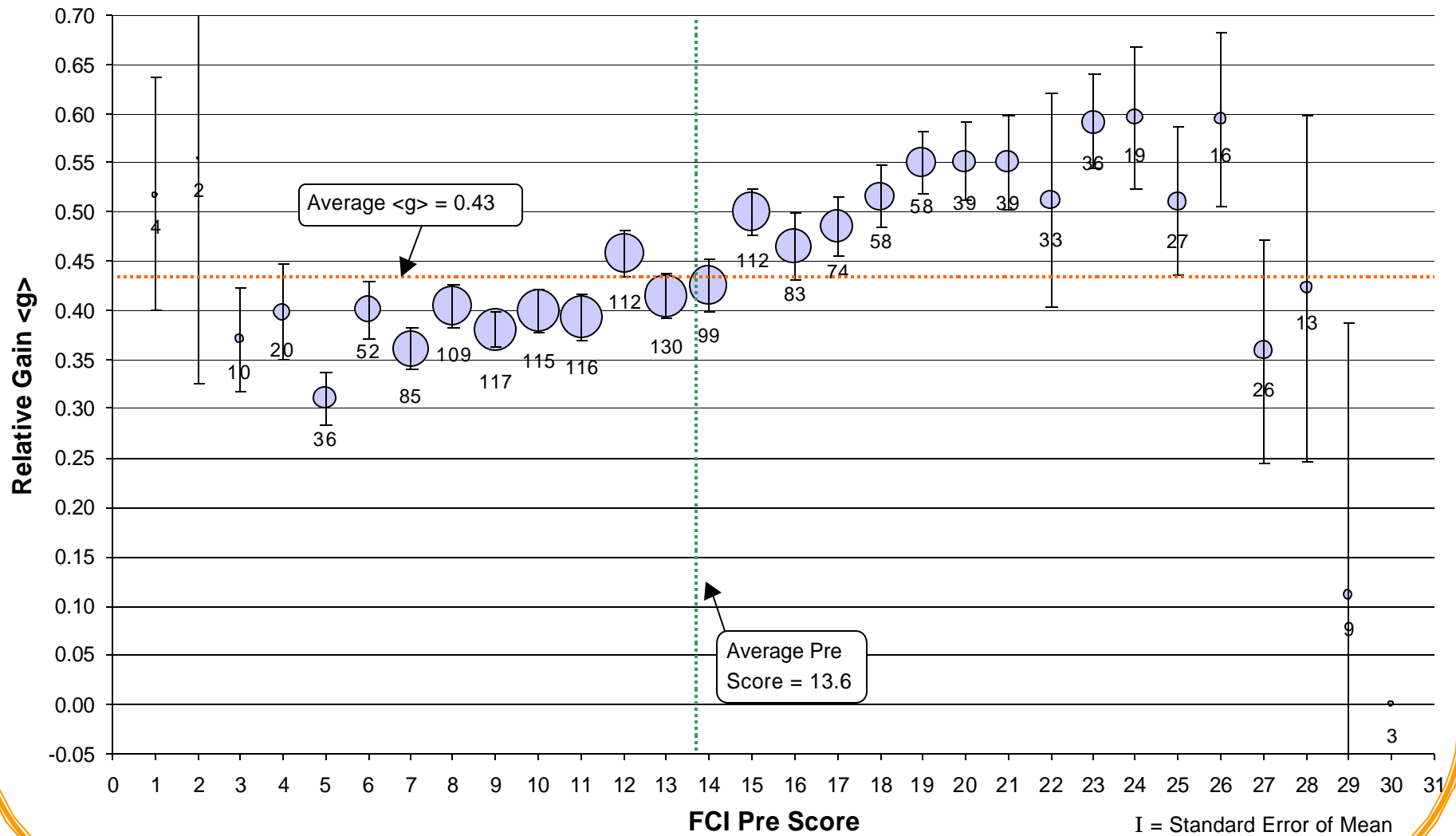


# Who Gains?

FCI pre vs. Relative Gain  $\langle g \rangle$

F97, F98, F99 All

N=1648





## **Question #6**

**Question: Are there gender differences in FCI scores?**

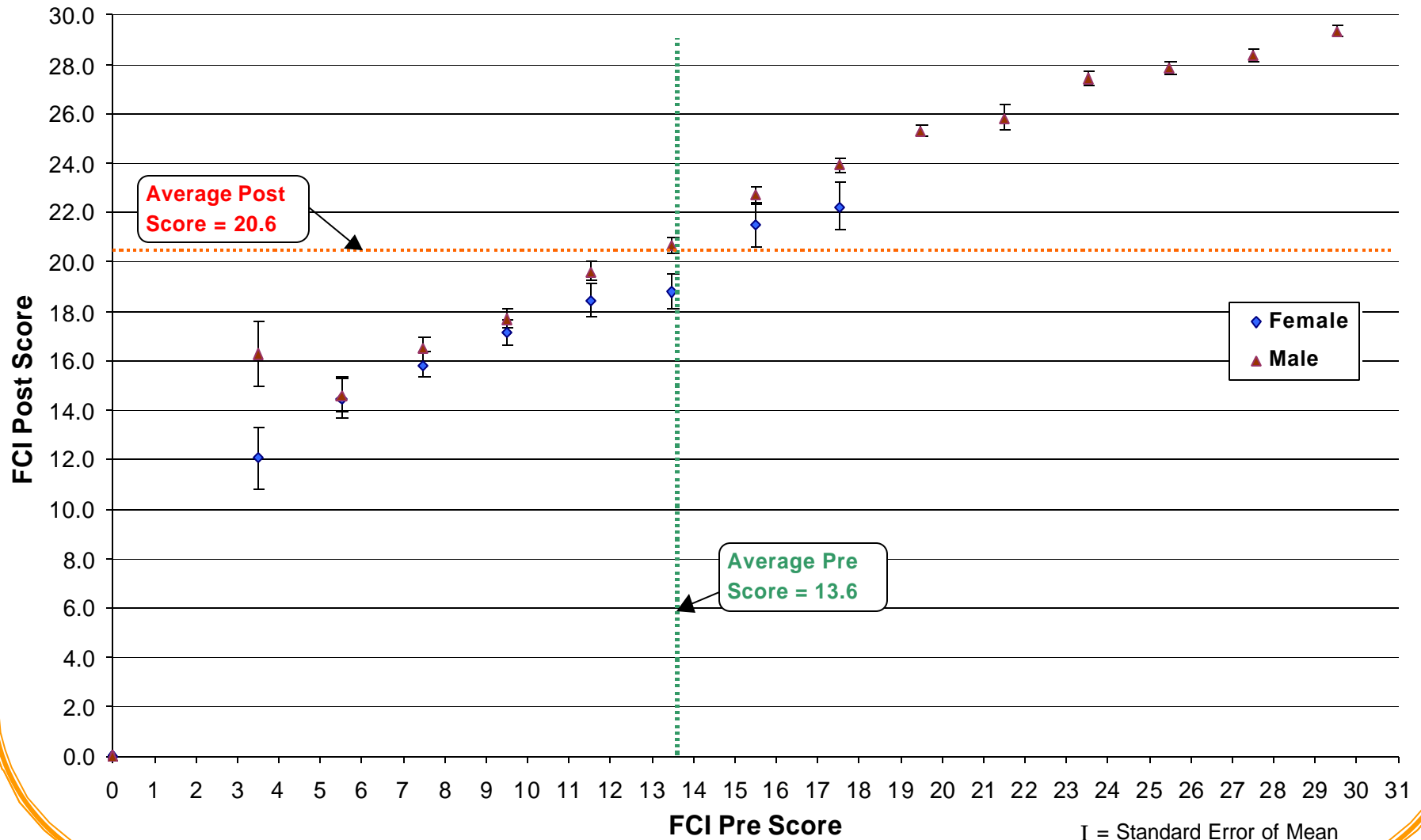
**Method: Compare the relationship between pre test and post test scores for males and females.**



# Gender Differences

FCI pre vs. FCI post  
F97, F98, F99 All, Binned by 2  
N=392 Female, N=1233 Male

Each point represents at least 10 students





# FCI Measurement Error

**Standard Error of Measurement = 2.18 items**

- **Based on Post Test data from Fall 1998 (similar for other years and pre test)**

$$N = 709$$

$$F_t = 5.45 \text{ items}$$

$$r = 0.84 \text{ (Cronbach alpha)}$$

- **Standard error of measurement is related to reliability**

$$F_e = F_t \sqrt{1 - r}$$

$F_e$  Ⓜ Standard error of measurement

$F_t$  Ⓜ Standard error of distribution of obtained scores

$r$  Ⓜ Reliability of test

- **This relationship comes from:**

1)  $F_{\text{total}}^2 = F_{\text{true}}^2 + F_{\text{error}}^2$

2)  $\text{Reliability} = F_{\text{true}}^2 / F_{\text{total}}^2 = 1 - F_{\text{error}}^2 / F_{\text{total}}^2$