Multiple predictors of performance in introductory general physics courses

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Acknowledgments

- Diagnostic data have been provided by (among others):

  Vince Coletta (Loyola Marymount University)

  Steven Pollock (University of Colorado, Boulder)

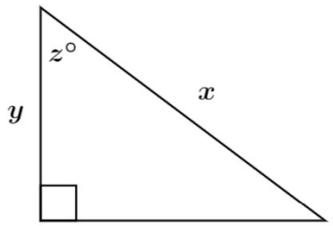
  Christopher Varney (University of West Florida)

Assessment Pretests

- Diagnostic pretest covering pre-college mathematics (“Math”)
  - calculators allowed
- Pre-instruction tests of scientific reasoning skill and physics concept knowledge:
  - Lawson Test of Scientific Reasoning (“Lawson”)
  - Force Concept Inventory (FCI)

Mathematics Diagnostic Pretest

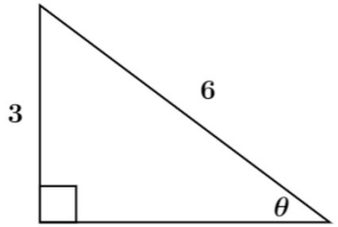
What is the length of side x?



A. $ycos(z°)$ D. $y/cos(z°)$ G. $cos(z°)/y$ J. $\sqrt{y^2+z^2}$
B. $ysin(z°)$ E. $y/sin(z°)$ H. $sin(z°)/y$ K. $\sqrt{z^2-y^2}$
C. $ytan(z°)$ F. $y/tan(z°)$ I. $tan(z°)/y$ L. y/z

(There may be more than one correct answer, but please select only ONE answer.)

What is the value of θ?



A. $cos(3/6)$ D. $cos^{-1}(3/6)$ G. $30°$ J. $27°$
B. $sin(3/6)$ E. $sin^{-1}(3/6)$ H. $45°$ K. $3/6$
C. $tan(3/6)$ F. $tan^{-1}(3/6)$ I. $60°$ L. 0.524

(There may be more than one correct answer, but please select only ONE answer.)

$cos(0°) = ?$

A. 0 B. 1 C. undefined D. 0.707 E. 0.894

(There may be more than one correct answer, but please select only ONE answer.)

$sin(90°) = ?$

A. 0 B. 1 C. undefined D. 0.707 E. 0.894

(There may be more than one correct answer, but please select only ONE answer.)

$tan(0°) = ?$

A. 0 B. 1 C. undefined D. 0.707 E. 0.894

(There may be more than one correct answer, but please select only ONE answer.)

Solve for θ.

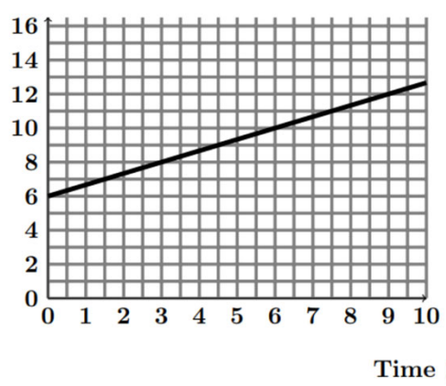
$\gamma\theta + \eta = \lambda\theta + \omega$

A. $\frac{\eta+\omega}{\gamma-\lambda}$ C. $\frac{\gamma-\lambda}{\omega-\eta}$ E. $\frac{\eta-\omega}{\gamma\lambda}$ G. $\frac{\omega-\eta}{\gamma-\lambda}$ I. $\frac{\eta-\omega+\gamma}{\lambda}$

B. $\frac{\eta-\omega}{\lambda-\gamma}$ D. $\frac{\lambda-\gamma}{\eta-\omega}$ F. $\frac{\omega-\eta}{\gamma\lambda}$ H. $\frac{\omega-\eta}{\gamma+\lambda}$ J. $\frac{\omega-\eta+\lambda}{\gamma}$

(There may be more than one correct answer, but please select only ONE answer.)

What is the slope of the graph below?



A. $\frac{1}{3}$ m/s because the object moves 1 meter in 3 seconds.

B. $\frac{1}{3}$ m/s because the line rises 1 box while it goes 3 boxes in the horizontal direction.

C. $\frac{2}{3}$ m/s because the object moves 2 meters in 3 seconds.

D. $\frac{2}{3}$ m/s because the line rises 2 boxes while it goes 3 boxes in the horizontal direction.

(There may be more than one correct answer, but please select only ONE answer.)

$$\left(\frac{a}{3}\right)^3 = ?$$

A. $\frac{a^3}{3}$ B. $\frac{a}{27}$ C. $\frac{a^3}{27}$

(There may be more than one correct answer, but please select only ONE answer.)

$$2\left(\frac{a}{b}\right) = ?$$

A. $\frac{2a}{b}$ B. $\frac{2a}{2b}$ C. $\frac{a}{2b}$

(There may be more than one correct answer, but please select only ONE answer.)

$$\frac{a/b}{c^2/d} = ?$$

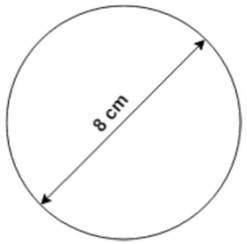
A. $\frac{ac^2}{bd}$ B. $\frac{ad}{bc^2}$ C. $\frac{bd}{ac^2}$ D. $\frac{bc^2}{ad}$

(There may be more than one correct answer, but please select only ONE answer.)

$$2\left(\frac{3}{4}\right) = ?$$

A. $\frac{6}{8}$ B. $\frac{12}{8}$ C. $\frac{3}{8}$ D. $\frac{3}{2}$ E. $\frac{3}{4}$

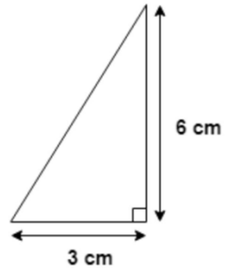
(There may be more than one correct answer, but please select only ONE answer.)



(a) Area of the circle = ?

A. 8π cm^3	F. 8π cm^2	K. 8π cm
B. 16π cm^3	G. 16π cm^2	L. 16π cm
C. 32π cm^3	H. 32π cm^2	M. 32π cm
D. 64π cm^3	I. 64π cm^2	N. 64π cm
E. 128π cm^3	J. 128π cm^2	O. 128π cm

(There may be more than one correct answer, but please select only ONE answer.)



(b) Area of the triangle = ?

A. 4.5 cm^3	F. 4.5 cm^2	K. 4.5 cm
B. 9 cm^3	G. 9 cm^2	L. 9 cm
C. 12 cm^3	H. 12 cm^2	M. 12 cm
D. 18 cm^3	I. 18 cm^2	N. 18 cm
E. 36 cm^3	J. 36 cm^2	O. 36 cm

(There may be more than one correct answer, but please select only ONE answer.)

Solve for x.

$$\frac{3}{2} = 7x$$

A. $\frac{14}{3}$ B. $\frac{3}{14}$ C. $\frac{21}{2}$ D. $\frac{21}{14}$

(There may be more than one correct answer, but please select only ONE answer.)

$$v^2 = v_0^2 + 2ad$$

$$v_0 = 0$$

$$a = \frac{\Delta v}{\Delta t}$$

$$\Delta v = 60$$

$$\Delta t = 8$$

$$v = 30$$

d =?

A. $d = 30$ B. $d = 60$ C. $d = 120$ D. $d = 240$ E. $d = 480$

(There may be more than one correct answer, but please select only ONE answer.)

$$cy = dx$$

$$a - y = bx$$

x =?

A. $\frac{ac}{d+b}$ C. $\frac{ac}{bc-d}$ E. $\frac{ac}{db}$ G. $\frac{a}{b+\frac{d}{c}}$ I. $\frac{1}{b}\left(a-\frac{d}{c}\right)$

B. $\frac{ac}{d-b}$ D. $\frac{ac}{bc+d}$ F. $\frac{a}{db}$ H. $\frac{a}{b+d}$ J. $\frac{c}{d}\left(a-b\right)$

(There may be more than one correct answer, but please select only ONE answer.)

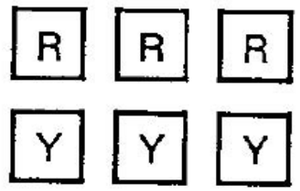
Scientific reasoning skills: The 24-item Lawson test

Suppose you are given two clay balls of equal size and shape. The two clay balls also weigh the same. One ball is flattened into a pancake-shaped piece. *Which of these statements is correct?*

a. The pancake-shaped piece weighs more than the ball
b. The two pieces still weigh the same
c. The ball weighs more than the pancake-shaped piece

Understanding shape-independence of mass

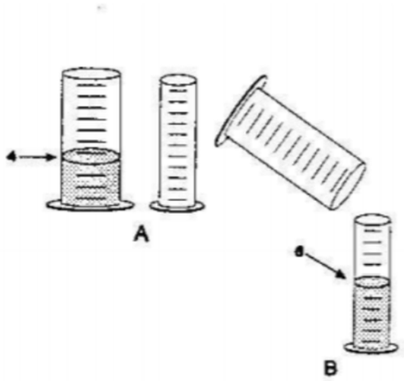
Six square pieces of wood are put into a cloth bag and mixed about. The six pieces are identical in size and shape, however, three pieces are red and three are yellow. Suppose someone reaches into the bag (without looking) and pulls out one piece. *What are the chances that the piece is red?*



a. 1 chance out of 6
b. 1 chance out of 3
c. 1 chance out of 2
d. 1 chance out of 1
e. cannot be determined

Probabilistic reasoning

To the right are drawings of a wide and a narrow cylinder. The cylinders have equally spaced marks on them. Water is poured into the wide cylinder up to the 4th mark (see A). This water rises to the 6th mark when poured into the narrow cylinder (see B).

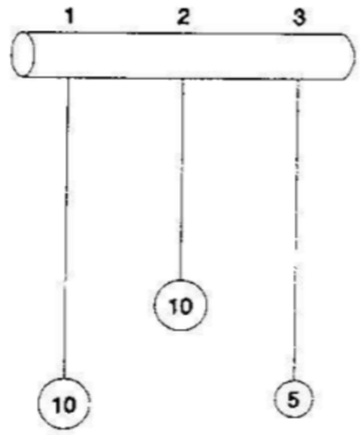


Both cylinders are emptied (not shown) and water is poured into the wide cylinder up to the 6th mark. *How high would this water rise if it were poured into the empty narrow cylinder?*

a. to about 8
b. to about 9
c. to about 10
d. to about 12
e. none of these answers is correct

Proportional reasoning

At the right are drawings of three strings hanging from a bar. The three strings have metal weights attached to their ends. String 1 and String 3 are the same length. String 2 is shorter. A 10 unit weight is attached to the end of String 1. A 10 unit weight is also attached to the end of String 2. A 5 unit weight is attached to the end of String 3. The strings (and attached weights) can be swung back and forth and the time it takes to make a swing can be timed.

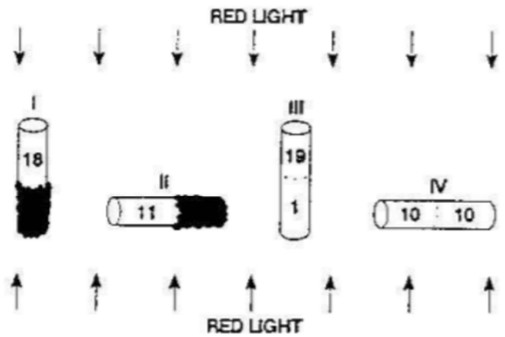


Suppose you want to find out whether the length of the string has an effect on the time it takes to swing back and forth. *Which strings would you use to find out?*

a. only one string
b. all three strings
c. 2 and 3
d. 1 and 3
e. 1 and 2

Control of variables

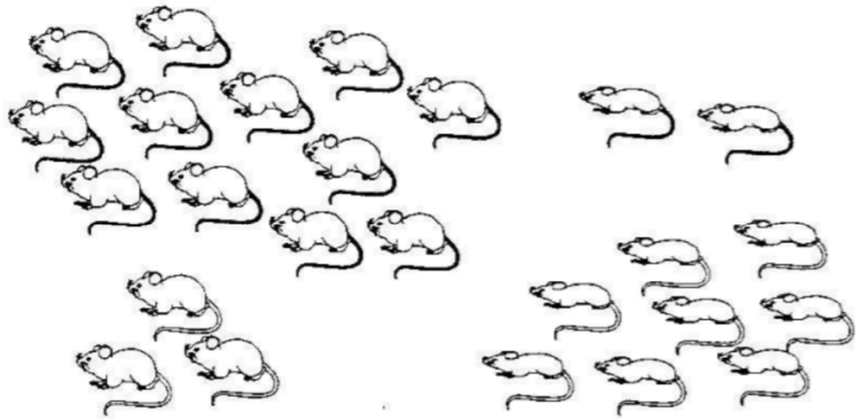
Twenty fruit flies are placed in each of four glass tubes. The tubes are sealed. Tubes I and II are partially covered with black paper; Tubes III and IV are not covered. The tubes are placed as shown. Then they are exposed to red light for five minutes. The number of flies in the uncovered part of each tube is shown in the drawing.



This experiment shows that flies respond to (respond means move to or away from):

a. red light but not gravity
b. gravity but not red light
c. both red light and gravity
d. neither red light nor gravity

Farmer Brown was observing the mice that live in his field. He discovered that all of them were either fat or thin. Also, all of them had either black tails or white tails. This made him wonder if there might be a link between the size of the mice and the color of their tails. So he captured all of the mice in one part of his field and observed them. Below are the mice that he captured.



Do you think there is a link between the size of the mice and the color of their tails?

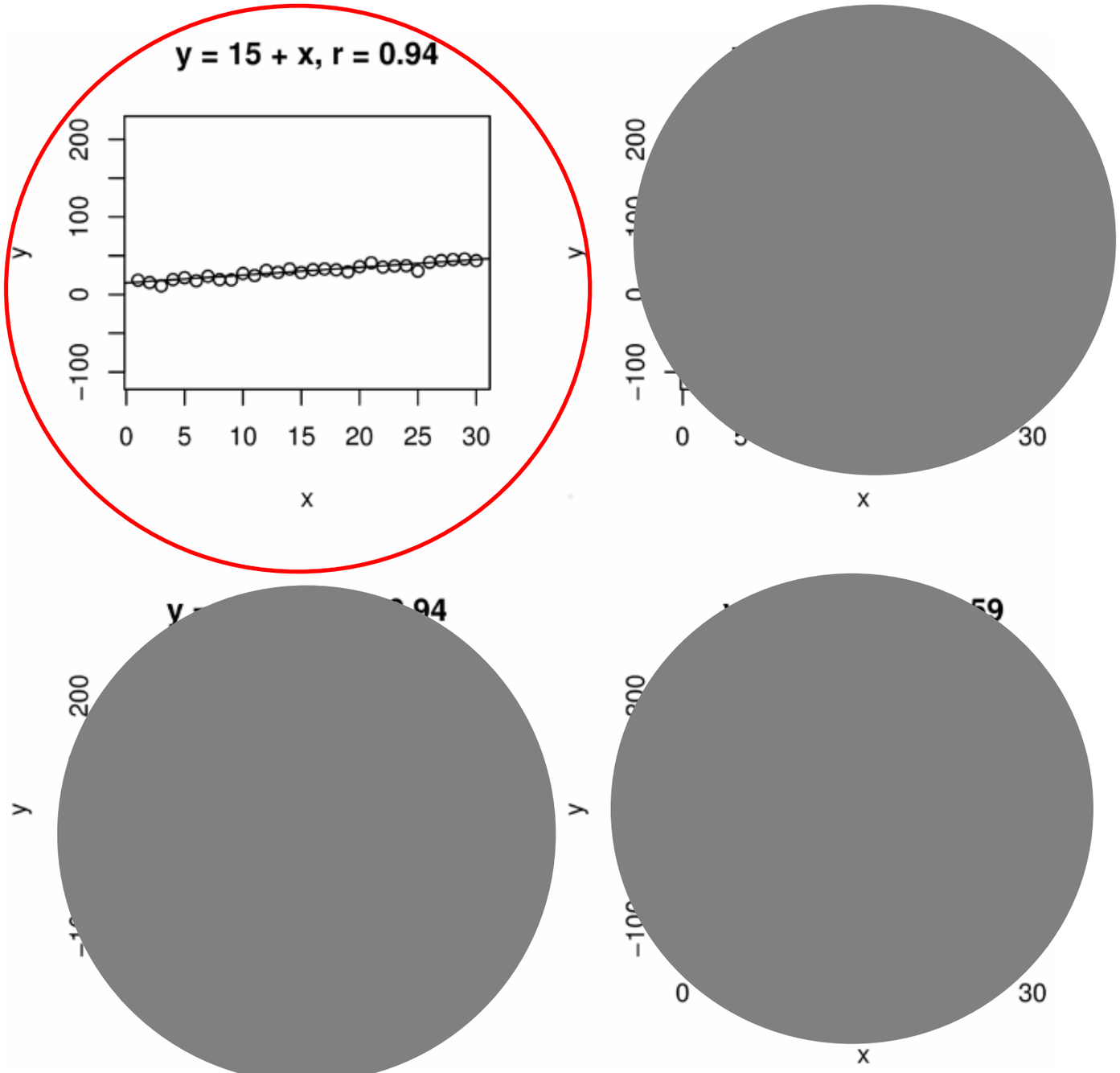
a. appears to be a link
b. appears not to be a link
c. cannot make a reasonable guess

Correlational reasoning

Relation Between Scores and Grades

- Correlation coefficients between pretest scores and final course grades vary greatly from course to course:
  - $r \approx +0.10 - +0.50$.
- However, slopes of fit lines for grades vs. pretest score are relatively high, therefore…
- …pretest scores on diagnostic assessments can approximately predict *probabilities* of final course grades

High correlation, small slope:
Changes in predictor variable have little effect (though highly predictable)



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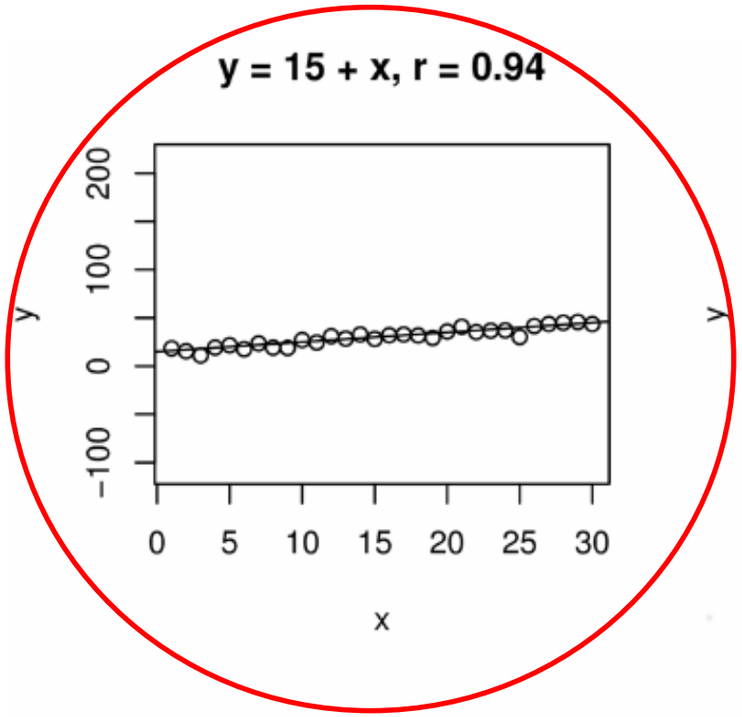

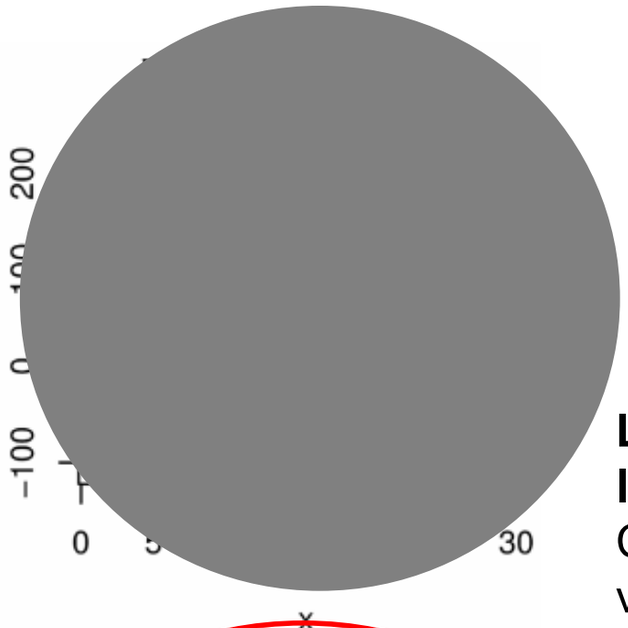

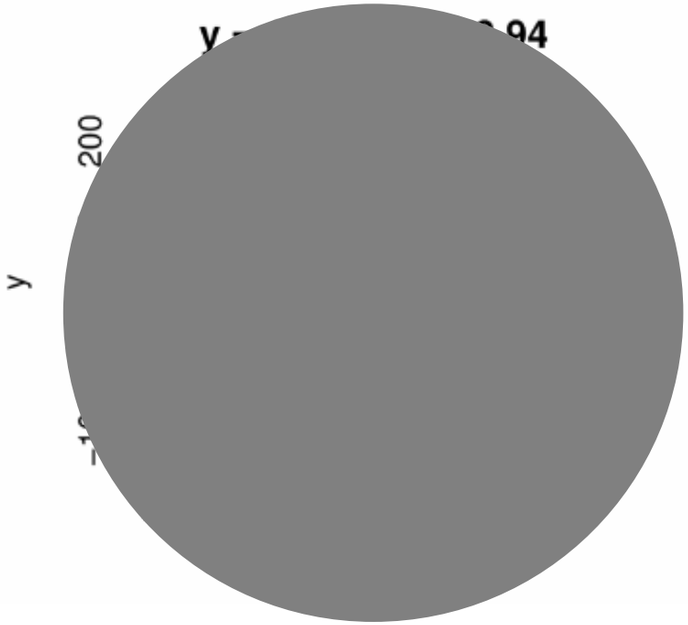

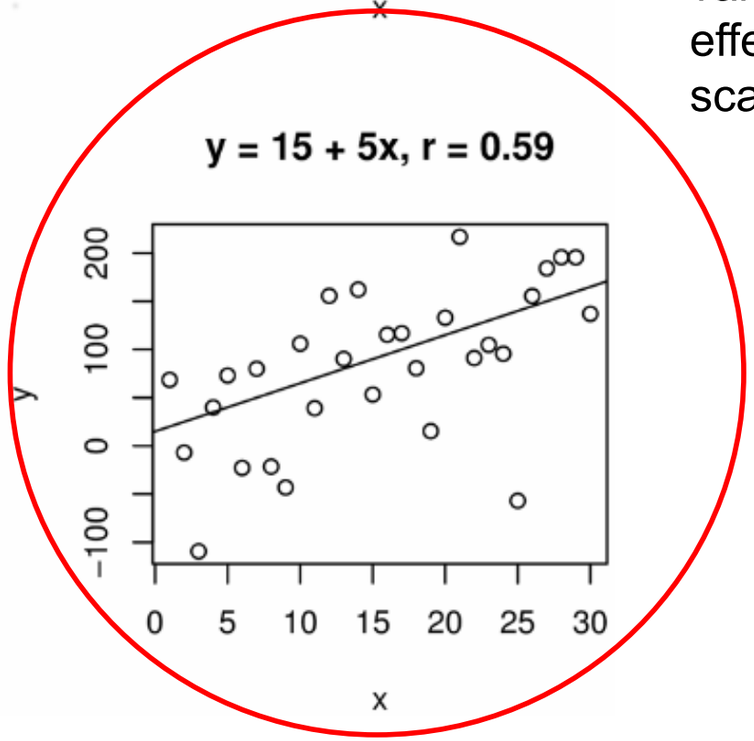

Low correlation, large slope:
Changes in predictor variable have large effect (despite large scatter)

High correlation, small slope:
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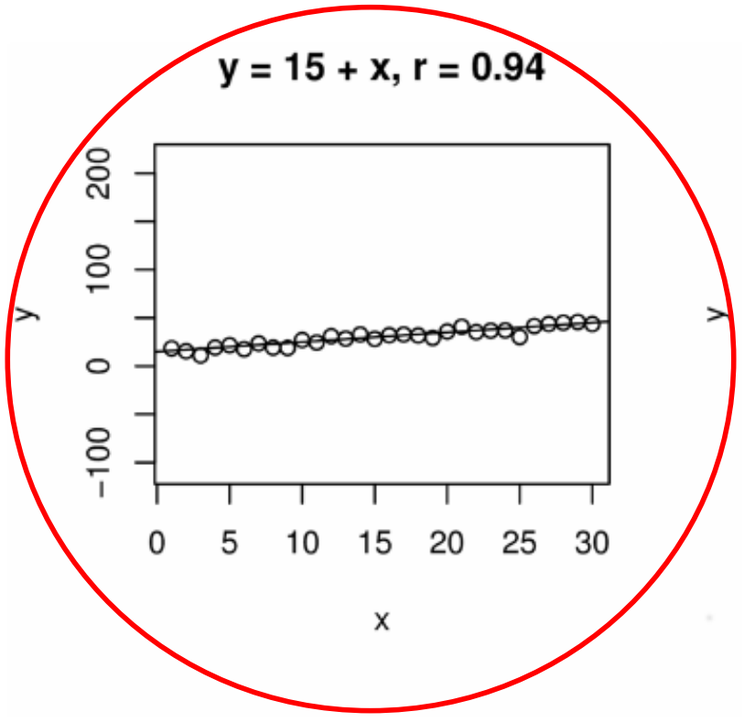

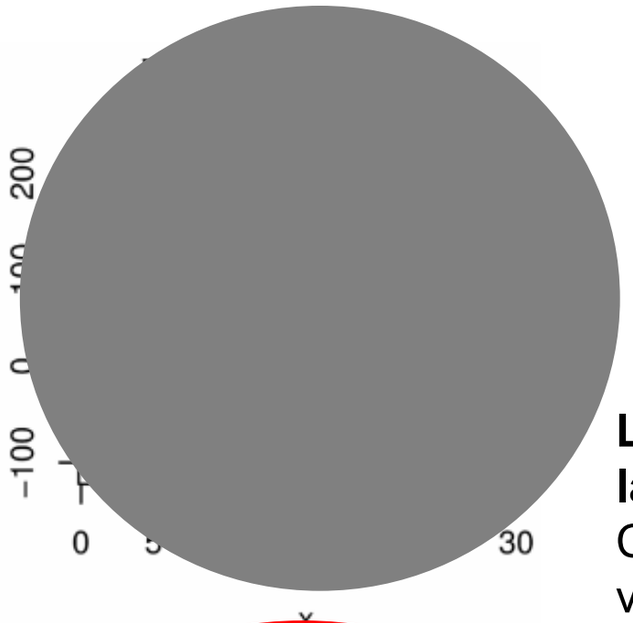

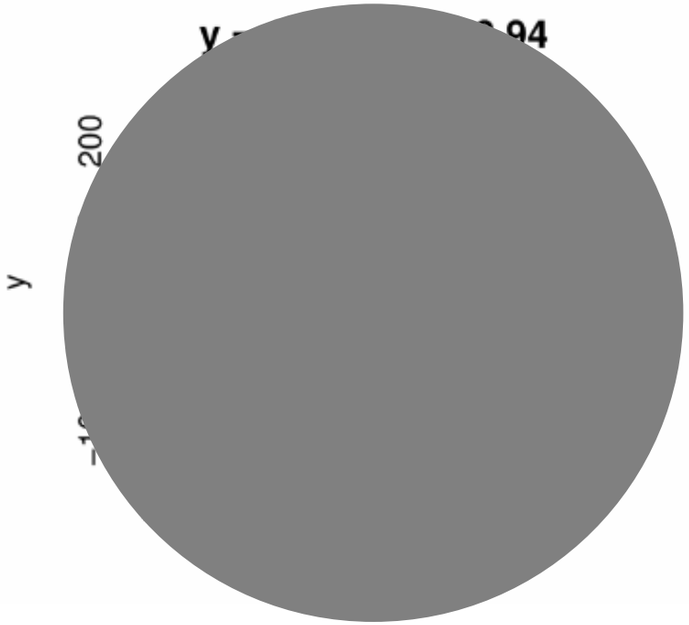

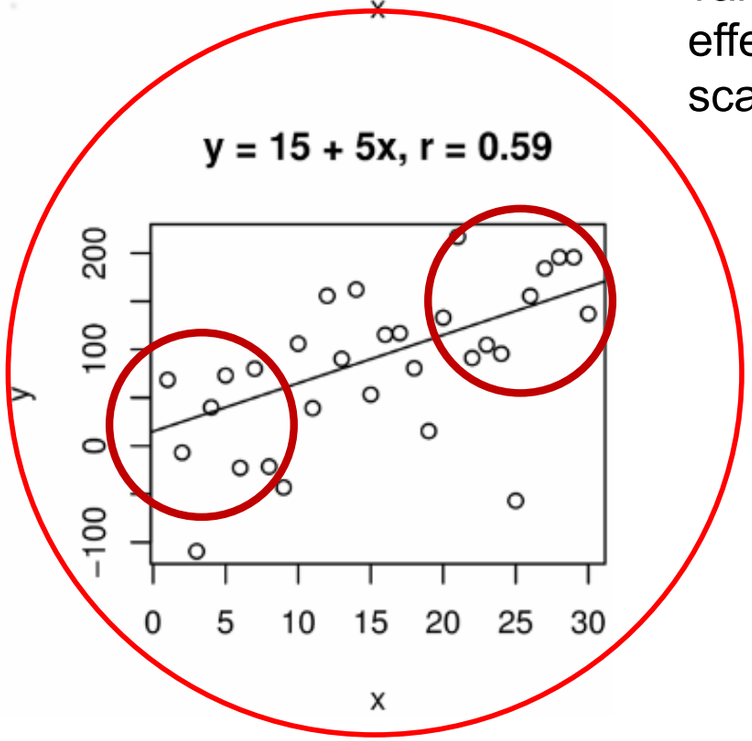

Low correlation, large slope:
Changes in predictor variable have large effect (despite large scatter)

What varies from class to class?

- Specific sets of variables that yield best fit in multivariable linear regressions—there is no universal “best fit” model.

What does not vary from class to class?

- Students with high scores on diagnostic pretests have much higher probability of receiving high grades than students with low pretest scores, and much lower probability of receiving low grades.

What does not vary[1] from class to class?

- Students with high scores on diagnostic pretests have much higher probability of receiving high grades than students with low pretest scores, and much lower probability of receiving low grades.

[1]true in 95% of cases observed

What does not vary[1] from class to class?

- Students with high[2] scores on diagnostic pretests have much higher probability of receiving high[2] grades than students with low pretest scores, and much lower probability of receiving low grades.

[1]true in 95% of cases observed

[2]top quartile in their class

What does not vary[1] from class to class?

- Students with high[2] scores on diagnostic pretests have much[3] higher probability of receiving high[2] grades than students with low pretest scores, and much[3] lower probability of receiving low grades.

[1]true in 95% of cases observed

[2]top quartile in their class

[3]generally between 200-500%

What does not vary[1] from class to class?

- Students with high[2] scores on diagnostic pretests have much[3] higher probability of receiving high[2] grades than students with low[4] pretest scores, and much[3] lower probability of receiving low[4] grades.

[1]true in 95% of cases observed

[2]top quartile in their class

[3]generally between 200-500%

[4]bottom quartile in their class

Comparing probabilities of high and low grades

- What is the probability of a student with a high score on a pre-instruction assessment getting a high grade in the class?
- How does that compare to a low-scoring student's probability of getting a high grade?
- What is the probability of a student with a high score on a pre-instruction assessment getting a low grade in the class?
- How does that compare to a low-scoring student's probability of getting a low grade?

Sample Description

- 25 introductory physics classes from 4 universities, over 2000 total students
- Instruction in most classes was “non-traditional,” generally highly interactive using research-based instructional materials and methods

Course and Institution Code

Alg-1: Algebra-based course, first semester

Alg-2: Algebra-based course, second semester

Calc-1: Calculus-based course, first semester

Calc-2: Calculus-based course, second semester

ASU-P: Arizona State University, Polytechnic campus

ASU-T: Arizona State University, Tempe campus

LMU: Loyola Marymount University

UWF: University of West Florida

CU: University of Colorado, Boulder

Consistent result:

High (top-quartile) scorers on the diagnostic pretests were much more likely to get ***high*** (top-quartile) grades than were low scorers

High Course Grade vs. Mathematics Diagnostic Pretest Score

Course	Campus	*N*	Top-quartile Math: % with top-quartile grades	Bottom-quartile Math: % with top-quartile grades	High-grade odds ratio
Alg-1 2021a	ASU-P	39	51%	10%	5.0
Alg-1 2021b	ASU-P	42	44%	10%	4.6
Alg-1 2022a	ASU-P	40	27%	6%	4.4
Alg-1 2022b	ASU-P	52	49%	10%	5.1
Alg-1 2023a	ASU-P	42	39%	10%	4.1
Alg-1 2023b	ASU-P	46	64%	9%	7.3
Alg-2 2022	ASU-P	75	46%	21%	2.2
Alg-2 2023	ASU-P	92	41%	13%	3.2
Alg-2 2021	ASU-T	129	30%	39%	0.8
Calc-1 2021a	UWF	53	43%	0%	“∞”
Calc-1 2021b	UWF	42	43%	0%	“∞”
Calc-2 2021	UWF	58	43%	14%	3.1
AVERAGE	**(unweighted)**	**(710)**	**43%**	**12%**	**3.7**

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AVERAGE	(unweighted)	(710)	43%	12%	3.7

High scorers on math pretest were 3.7 times more likely to get a high grade than were low scorers

High Course Grade vs. Lawson Test of Scientific Reasoning Pretest Score

Course	Campus	*N*	Top-quartile Lawson: % with top-quartile grades	Bottom-quartile Lawson: % with top-quartile grades	High-grade odds ratio
Alg-1 2021a	ASU-P	35	46%	23%	2.0
Alg-1 2021b	ASU-P	38	32%	8%	4.0
Alg-1 2022a	ASU-P	41	49%	10%	5.0
Alg-1 2022b	ASU-P	54	57%	10%	5.6
Alg-1 2023a	ASU-P	36	39%	33%	1.2
Alg-1 2023b	ASU-P	44	55%	9%	6.0
Alg-2 2022	ASU-P	73	41%	6%	7.6
Alg-2 2023	ASU-P	92	52%	10%	5.0
Alg-1	CU	469	45%	8%	5.5
Calc-2	CU	276	57%	8%	6.9
Alg-1 2007	LMU	24	50%	0%	“∞”
Alg-1 2009	LMU	51	34%	11%	3.2
Alg-1 2011	LMU	57	53%	18%	2.9
Alg-1 2012	LMU	44	64%	6%	10.5
Alg-1 2013	LMU	30	53%	12%	4.6
Alg-1 2014	LMU	33	61%	0%	“∞”
Alg-1 2015	LMU	24	63%	0%	“∞”
Alg-1 2016	LMU	35	41%	0%	“∞”
Alg-1 2018	LMU	47	54%	9%	6.3
Alg-1 2021	LMU	27	44%	0%	“∞”
AVERAGE	**(unweighted)**	**(1530)**	**50%**	**9%**	**5.5**

High Course Grade vs. Lawson Test of Scientific Reasoning Pretest Score

	Campus	*N*	Top-quartile Lawson: % with top-quartile grades	Bottom-quartile Lawson: % with top-quartile grades	High-grade odds ratio
Alg-1 2021	LMU	27	44%	0%	"∞"
AVERAGE	(unweighted)	(1530)	**50%**	**9%**	**5.5**

High scorers on Lawson pretest were 5.5 times more likely to get a high grade than were low scorers

High Course Grade vs. FCI

Course	Campus	*N*	Top-quartile FCI: % with top-quartile grades	Bottom-quartile FCI: % with top-quartile grades	High-grade odds ratio
Alg-1 2018	ASU-P	48	40%	8%	4.8
Alg-1 2019	ASU-P	63	38%	13%	3.0
Alg-1 2021a	ASU-P	35	57%	0%	“∞”
Alg-1 2021b	ASU-P	37	32%	17%	1.9
Alg-1 2022a	ASU-P	41	21%	15%	1.4
Alg-1 2022b	ASU-P	52	26%	7%	3.9
Alg-1 2023a	ASU-P	40	30%	20%	1.3
Alg-1 2023b	ASU-P	47	55%	18%	3.1
Alg-1	CU	470	41%	12%	3.5
Alg-1 2007	LMU	23	87%	0%	“∞”
Alg-1 2009	LMU	51	63%	0%	“∞”
Alg-1 2012	LMU	44	50%	0%	“∞”
Alg-1 2013	LMU	30	51%	0%	“∞”
Alg-1 2014	LMU	33	43%	12%	3.6
Alg-1 2015	LMU	24	67%	0%	“∞”
Alg-1 2016	LMU	34	71%	0%	“∞”
Alg-1 2018	LMU	47	34%	14%	2.4
Alg-1 2021	LMU	27	44%	0%	“∞”
Calc-1 2012	ASU-P	40	43%	0%	“∞”
Calc-1 2013a	ASU-P	18	44%	0%	“∞”
Calc-1 2013b	ASU-P	48	54%	17%	3.3
Calc-1 2021a	UWF	62	29%	26%	1.1
Calc-1 2021b	UWF	53	40%	15%	2.6
AVERAGE	**(unweighted)**	**(1367)**	**46%**	**8%**	**5.4**

High Course Grade vs. FCI

ıpus	*N*	Top-quartile FCI: % with top-quartile grades	Bottom-quartile FCI: % with top-quartile grades	High-grade odds ratio
	48	40%	8%	4.8
		40%	15%	2.8
AVERAGE	(unweighted) (1367)	**46%**	**8%**	**5.4**

High scorers on FCI pretest were 5.4 times more likely to get a high grade than were low scorers

High scorers on Math pretest were 3.7 times more likely to get a high grade than were low scorers

High scorers on Lawson pretest were 5.5 times more likely to get a high grade than were low scorers

High scorers on FCI pretest were 5.4 times more likely to get a high grade than were low scorers

What about probabilities of getting low grades?

Low Course Grade vs. Mathematics Diagnostic Pretest Score

Course	Campus	*N*	Top-quartile Math: % with bottom-quartile grades	Bottom-quartile Math: % with bottom-quartile grades	Low-grade odds ratio
Alg-1 2021a	ASU-P	39	10%	41%	4.0
Alg-1 2021b	ASU-P	42	16%	48%	3.0
Alg-1 2022a	ASU-P	40	0%	42%	“∞”
Alg-1 2022b	ASU-P	52	26%	29%	1.1
Alg-1 2023a	ASU-P	42	20%	31%	1.5
Alg-1 2023b	ASU-P	46	3%	21%	7.3
Alg-2 2022	ASU-P	75	11%	26%	2.4
Alg-2 2023	ASU-P	92	11%	30%	2.8
Alg-2 2021	ASU-T	129	11%	30%	2.8
Calc-1 2021a	UWF	53	0%	41%	“∞”
Calc-1 2021b	UWF	42	19%	38%	2.0
Calc-2 2021	UWF	58	24%	44%	1.8
AVERAGE	**(unweighted)**	**(710)**	**13%**	**35%**	**2.8**

Low scorers on Math pretest were 2.8 times more likely to get a low grade than were high scorers

Low Course Grade vs. Lawson Test of Scientific Reasoning Pretest Score

Course	Campus	*N*	Top-quartile Lawson: % with bottom-quartile grades	Bottom-quartile Lawson: % with bottom-quartile grades	Low-grade odds ratio
Alg-1 2021a	ASU-P	35	0%	34%	“∞”
Alg-1 2021b	ASU-P	38	11%	53%	5.0
Alg-1 2022a	ASU-P	41	15%	52%	3.5
Alg-1 2022b	ASU-P	54	15%	28%	1.9
Alg-1 2023a	ASU-P	36	14%	36%	2.6
Alg-1 2023b	ASU-P	44	9%	45%	5.0
Alg-2 2022	ASU-P	73	16%	27%	1.7
Alg-2 2023	ASU-P	92	13%	37%	2.8
Alg-1	CU	469	10%	42%	4.4
Calc-2	CU	276	12%	44%	3.8
Alg-1 2007	LMU	24	0%	58%	“∞”
Alg-1 2009	LMU	51	5%	48%	10.4
Alg-1 2011	LMU	57	15%	46%	3.0
Alg-1 2012	LMU	44	9%	27%	3.0
Alg-1 2013	LMU	30	27%	12%	0.4
Alg-1 2014	LMU	33	0%	68%	“∞”
Alg-1 2015	LMU	24	0%	75%	“∞”
Alg-1 2016	LMU	35	11%	46%	4.0
Alg-1 2018	LMU	47	16%	42%	2.7
Alg-1 2021	LMU	27	0%	89%	“∞”
AVERAGE	**(unweighted)**	**(1530)**	**10%**	**45%**	**4.6**

Low scorers on Lawson pretest were 4.6 times more likely to get a low grade than were high scorers

Low Course Grade vs. FCI

Course	Campus	*N*	Top-quartile FCI: % with bottom-quartile grades	Bottom-quartile FCI: % with bottom-quartile grades	Low-grade odds ratio
Alg-1 2018	ASU-P	48	21%	50%	2.4
Alg-1 2019	ASU-P	63	6%	47%	7.4
Alg-1 2021a	ASU-P	35	0%	56%	“∞”
Alg-1 2021b	ASU-P	37	11%	43%	4.0
Alg-1 2022a	ASU-P	41	21%	39%	1.9
Alg-1 2022b	ASU-P	52	18%	33%	1.8
Alg-1 2023a	ASU-P	40	20%	37%	1.8
Alg-1 2023b	ASU-P	47	9%	43%	5.1
Alg-1	CU	470	19%	22%	1.1
Alg-1 2007	LMU	23	0%	52%	“∞”
Alg-1 2009	LMU	51	8%	47%	6.0
Alg-1 2012	LMU	44	9%	50%	5.4
Alg-1 2013	LMU	30	24%	37%	1.5
Alg-1 2014	LMU	33	7%	32%	4.7
Alg-1 2015	LMU	24	0%	67%	“∞”
Alg-1 2016	LMU	34	12%	47%	4.0
Alg-1 2018	LMU	47	15%	31%	2.2
Alg-1 2021	LMU	27	0%	44%	“∞”
Calc-1 2012	ASU-P	40	10%	43%	4.3
Calc-1 2013a	ASU-P	18	0%	44%	“∞”
Calc-1 2013b	ASU-P	48	17%	8%	0.5
Calc-1 2021a	UWF	62	13%	40%	3.1
Calc-1 2021b	UWF	53	8%	25%	3.3
AVERAGE	**(unweighted)**	**(1367)**	**11%**	**41%**	**3.8**

Low scorers on FCI pretest were 3.8 times more likely to get a low grade than were high scorers

Consistent result:

Low (bottom-quartile) scorers on the diagnostic pretests were much more likely to get ***low*** (bottom-quartile) grades than were high scorers

High scorers on Math pretest were 3.7 times more likely to get a high grade than were low scorers

High scorers on Lawson pretest were 5.5 times more likely to get a high grade than were low scorers

High scorers on FCI pretest were 5.4 times more likely to get a high grade than were low scorers

Low scorers on Math pretest were 2.8 times more likely to get a low grade than were high scorers

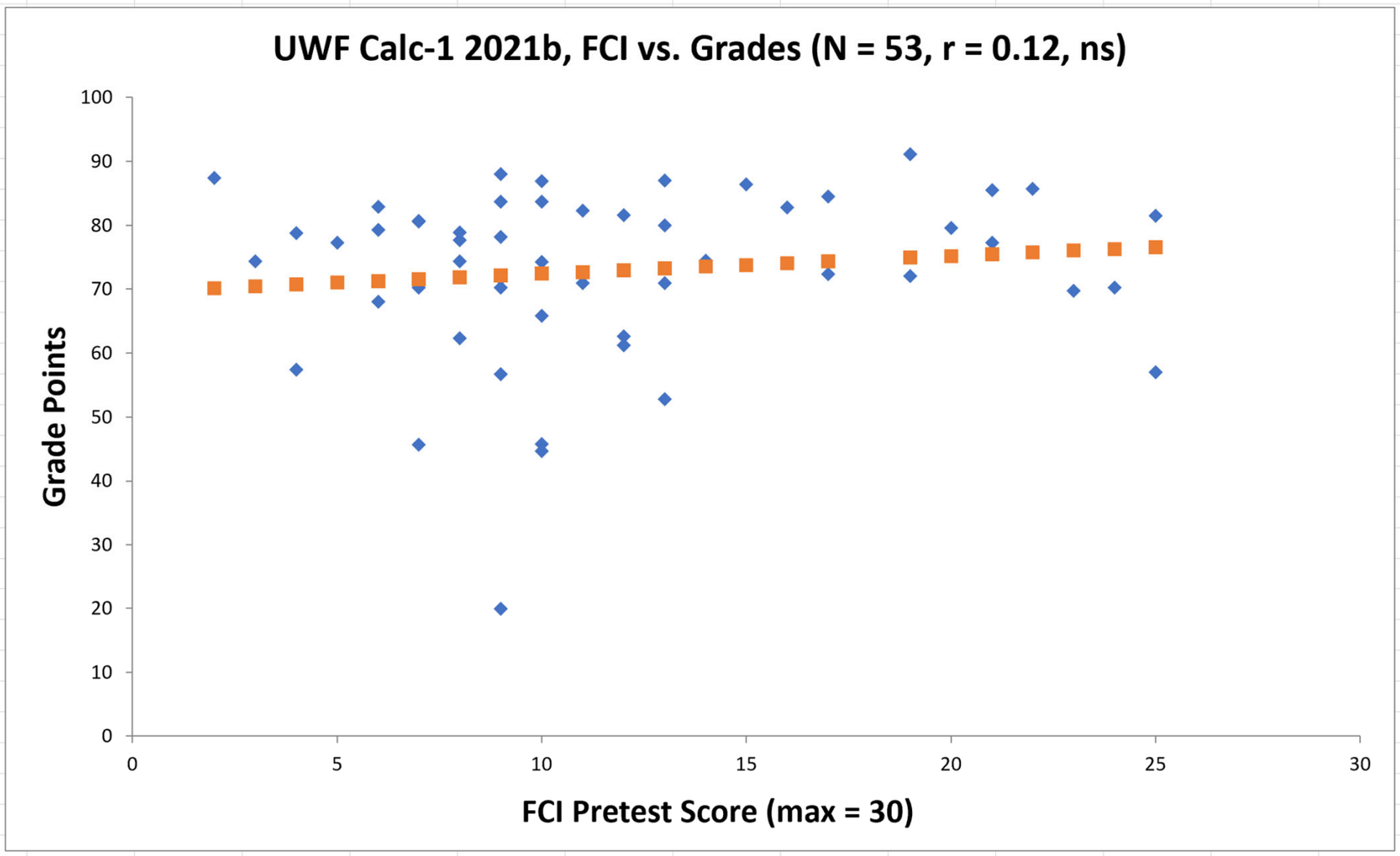
Low scorers on Lawson pretest were 4.6 times more likely to get a low grade than were high scorers

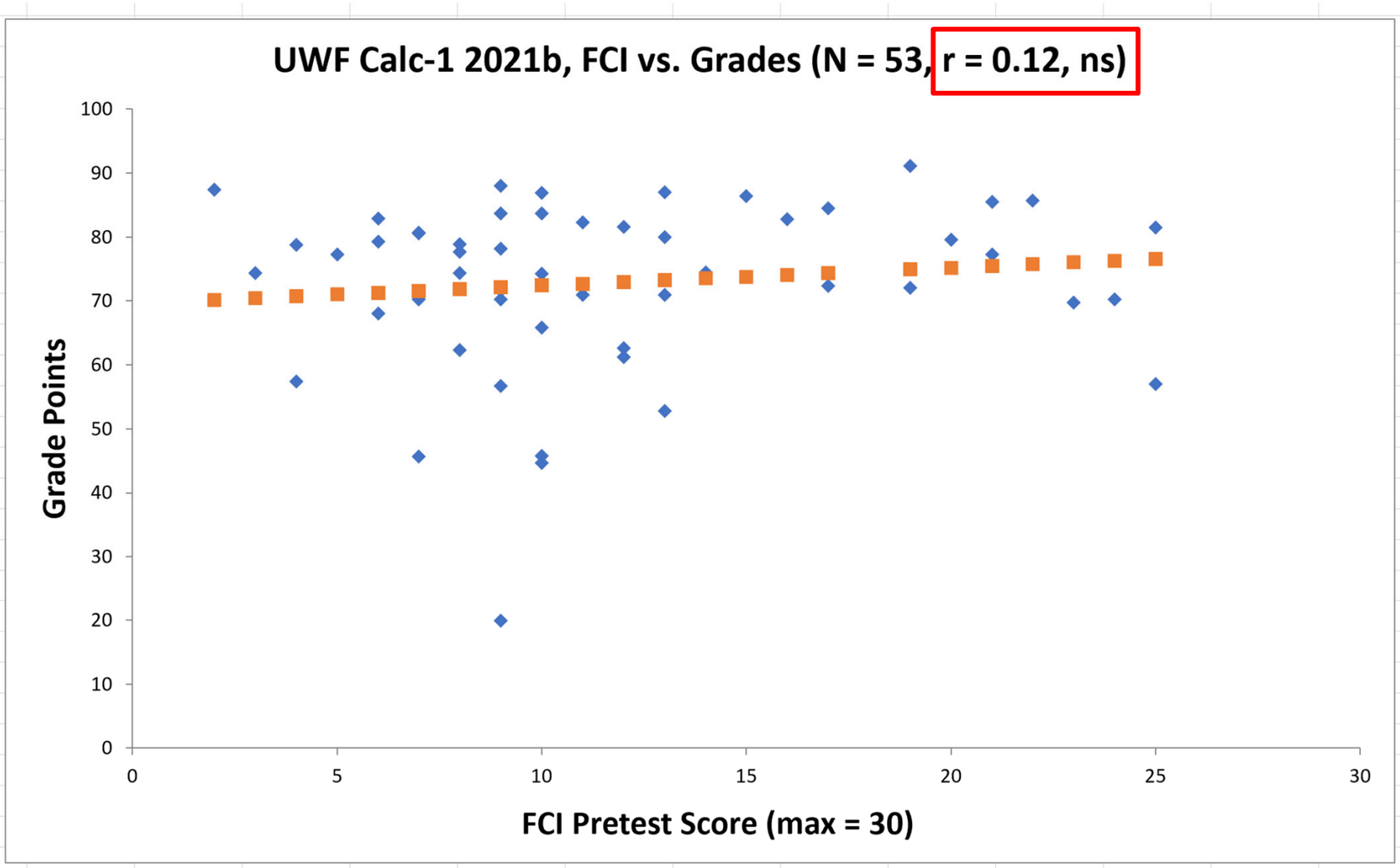
Low scorers on FCI pretest were 3.8 times more likely to get a low grade than were high scorers

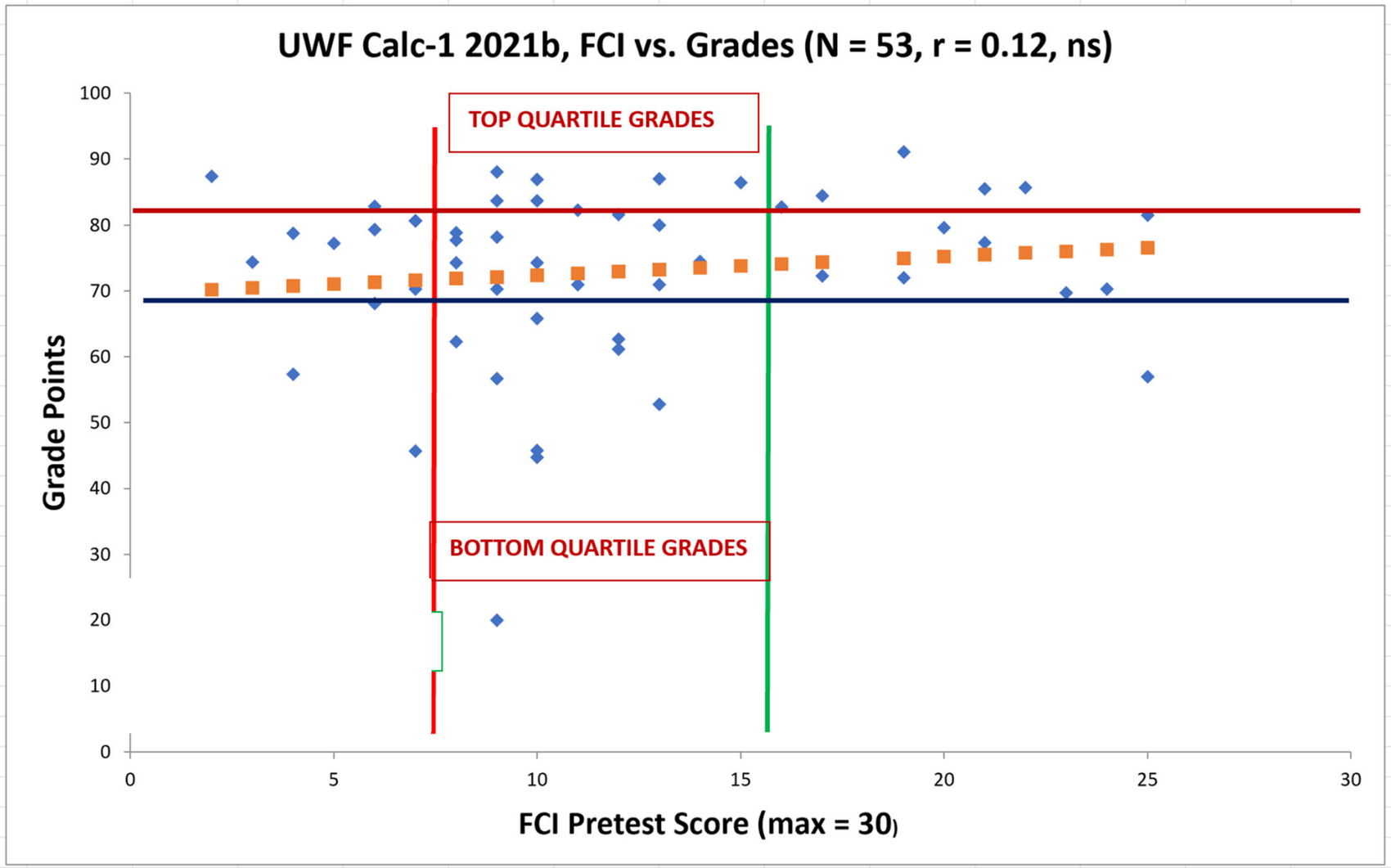
High and low grades for high and low scorers were compared in 12 classes for the math diagnostic, 20 classes for the Lawson pretest, and 23 classes for the FCI, a total of 110 high/low comparisons. ***The quartile ratios were greater than 1.0 in 107 of the 110 cases (97%)***.

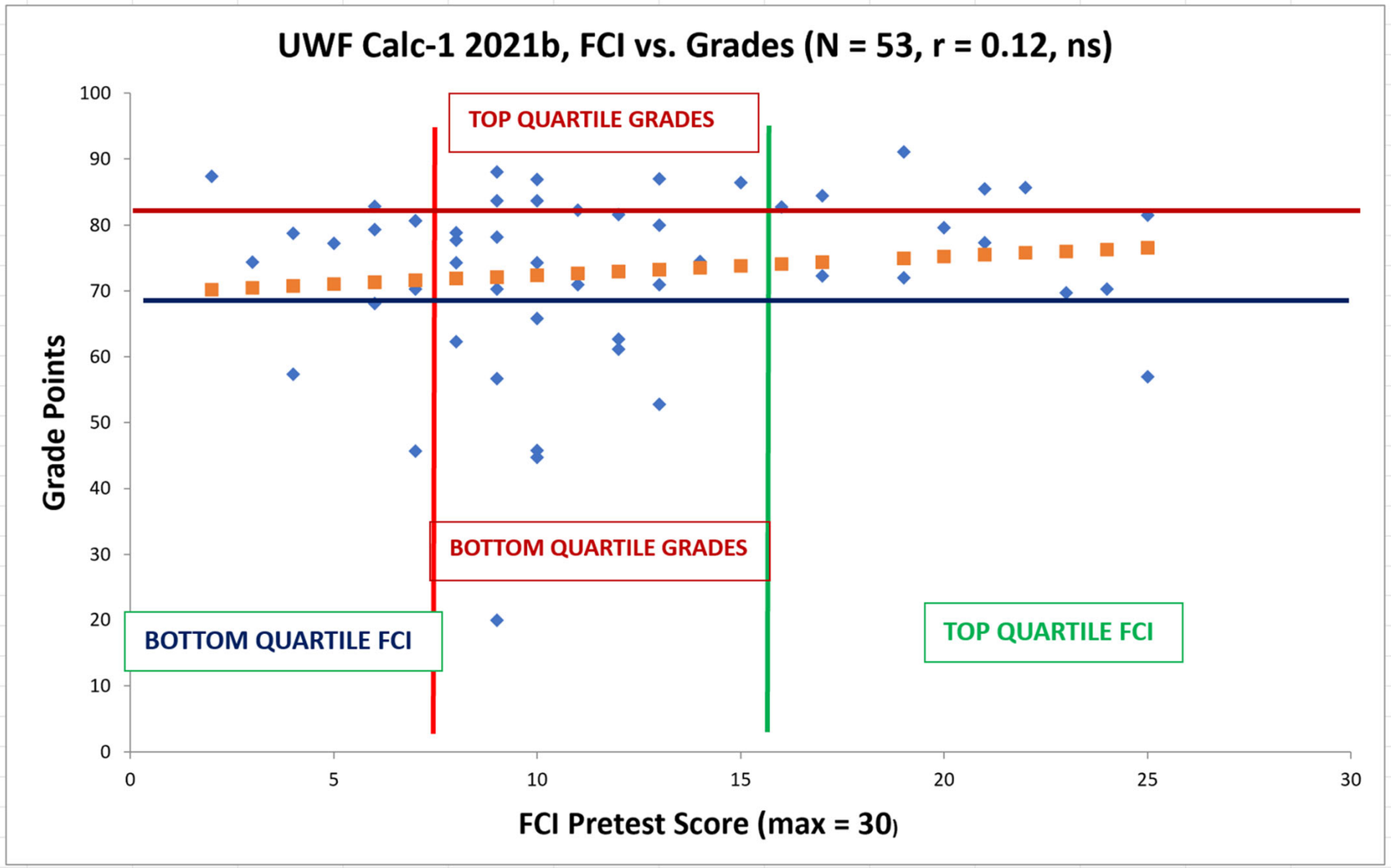
Regression analysis can be misleading

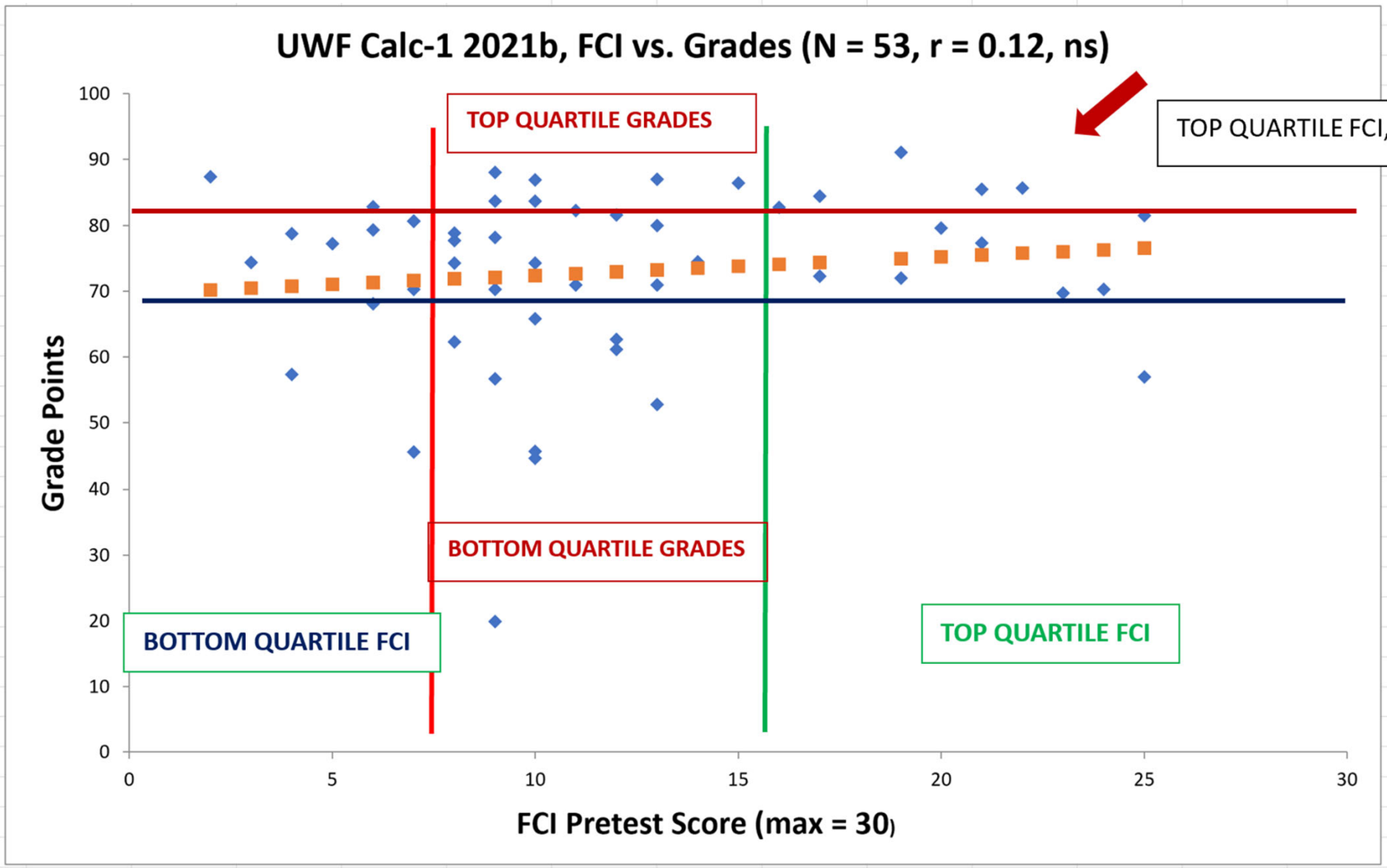
- High scatter in the data leads to relatively low correlation
- However, quartile comparison can reveal highly significant differences between low and high scorers


UWF Calc-1 2021b, FCI vs. Grades (N = 53, r = 0.12, ns)
Grade Points
100
90
80
70
60
50
40
30
20
10
0
0
5
10
15
20
25
30
FCI Pretest Score (max = 30)

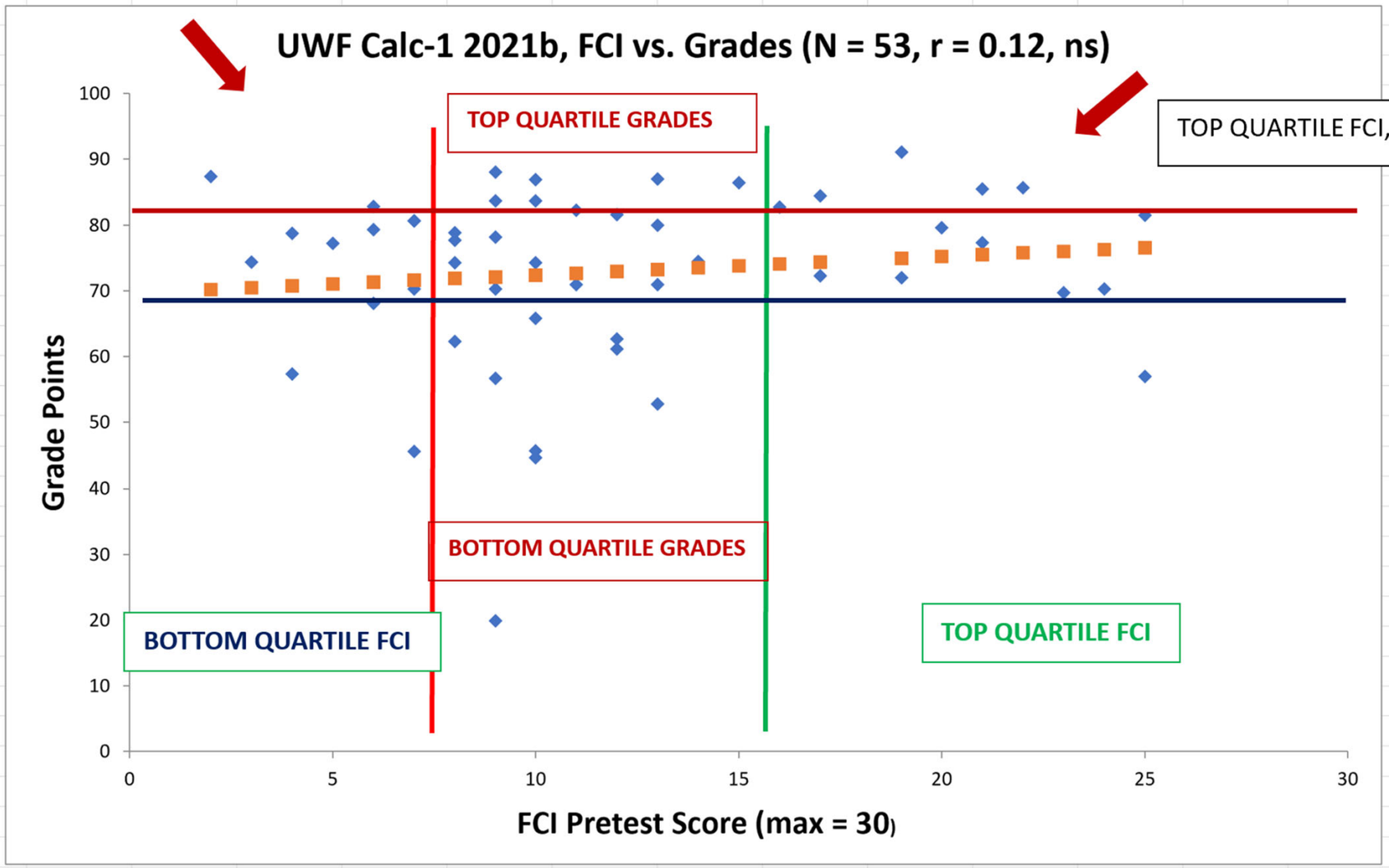

UWF Calc-1 2021b, FCI vs. Grades (N = 53, r = 0.12, ns)
Grade Points
100
90
80
70
60
50
40
30
20
10
0
0
5
10
15
20
25
30
FCI Pretest Score (max = 30)


UWF Calc-1 2021b, FCI vs. Grades (N = 53, r = 0.12, ns)
TOP QUARTILE GRADES
BOTTOM QUARTILE GRADES
Grade Points
FCI Pretest Score (max = 30)
0
10
20
30
40
50
60
70
80
90
100
0
5
10
15
20
25
30

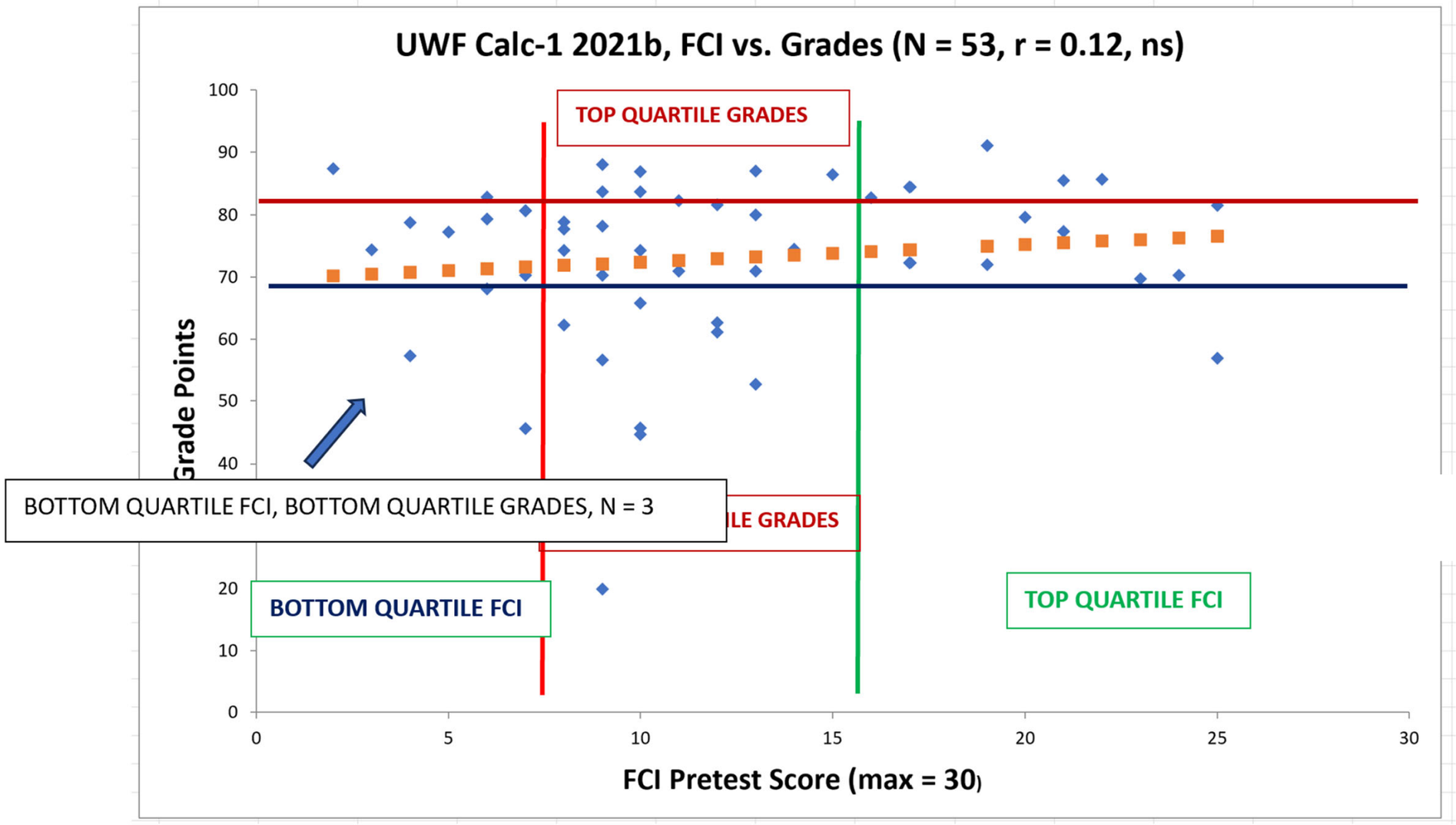

UWF Calc-1 2021b, FCI vs. Grades (N = 53, r = 0.12, ns)
TOP QUARTILE GRADES
BOTTOM QUARTILE GRADES
BOTTOM QUARTILE FCI
TOP QUARTILE FCI
Grade Points
FCI Pretest Score (max = 30)
0
10
20
30
40
50
60
70
80
90
100
0
5
10
15
20
25
30

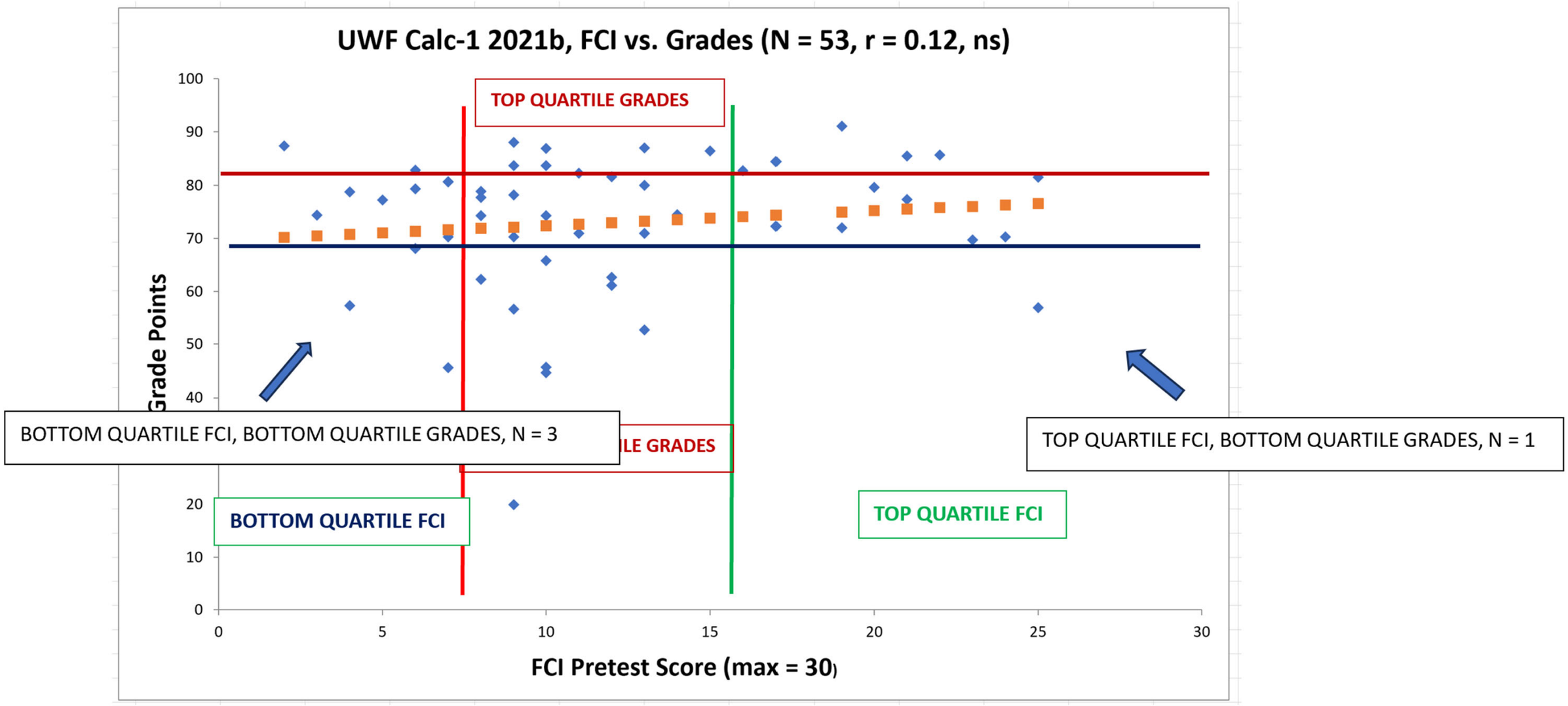

UWF Calc-1 2021b, FCI vs. Grades (N = 53, r = 0.12, ns)
TOP QUARTILE GRADES
BOTTOM QUARTILE GRADES
BOTTOM QUARTILE FCI
TOP QUARTILE FCI
TOP QUARTILE FCI, TOP QUARTILE GRADES, N = 5
Grade Points
FCI Pretest Score (max = 30)
0
10
20
30
40
50
60
70
80
90
100
0
5
10
15
20
25
30

BOTTOM QUARTILE FCI, TOP QUARTILE GRADES, N = 2



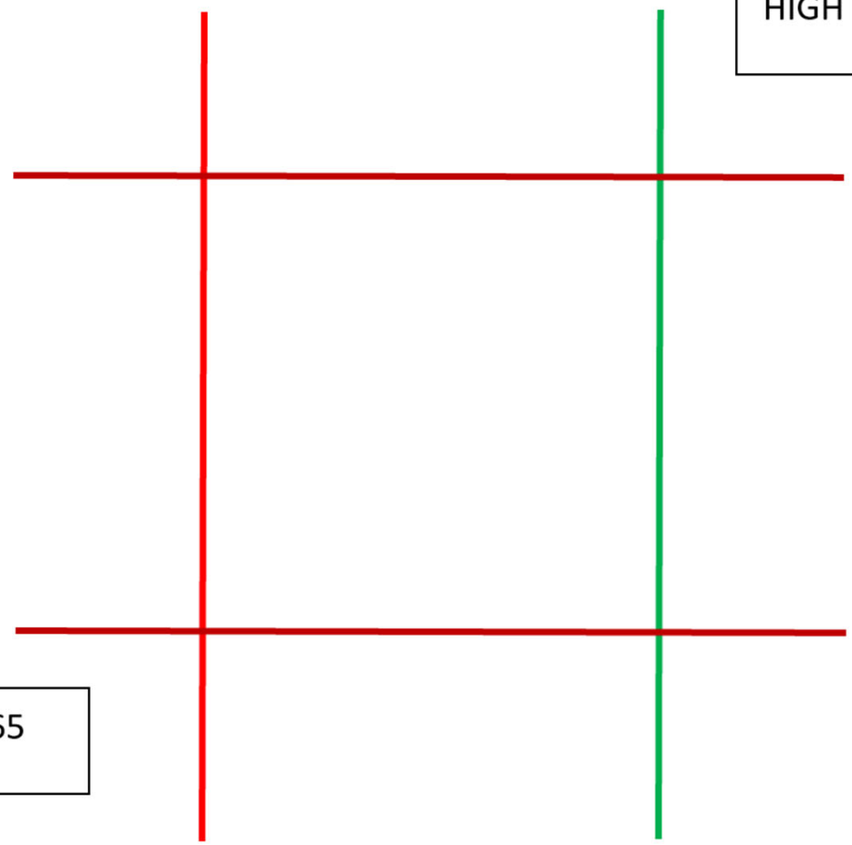
TOP QUARTILE FCI, TOP QUARTILE GRADES, N = 5


UWF Calc-1 2021b, FCI vs. Grades (N = 53, r = 0.12, ns)
TOP QUARTILE GRADES
BOTTOM QUARTILE FCI, BOTTOM QUARTILE GRADES, N = 3
BOTTOM QUARTILE FCI
TOP QUARTILE FCI
Grade Points
FCI Pretest Score (max = 30)
100
90
80
70
60
50
40
20
10
0
0
5
10
15
20
25
30


UWF Calc-1 2021b, FCI vs. Grades (N = 53, r = 0.12, ns)
TOP QUARTILE GRADES
ILE GRADES
BOTTOM QUARTILE FCI
TOP QUARTILE FCI
BOTTOM QUARTILE FCI, BOTTOM QUARTILE GRADES, N = 3
TOP QUARTILE FCI, BOTTOM QUARTILE GRADES, N = 1
Grade Points
FCI Pretest Score (max = 30)
0
10
20
30
40
50
60
70
80
90
100
0
5
10
15
20
25
30

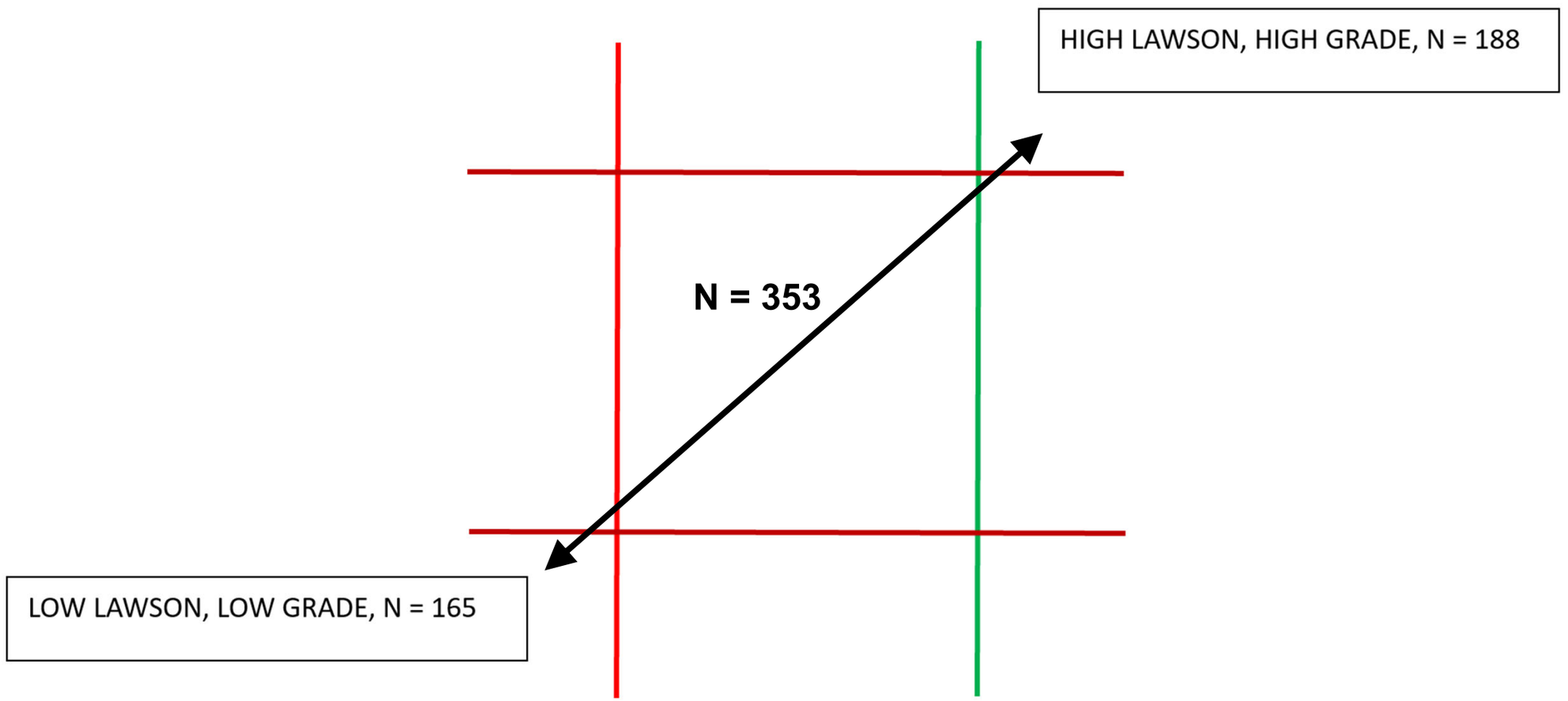
LAWSON PRETEST VS. GRADES, 20 CLASSES COMBINED

HIGH LAWSON, HIGH GRADE, N = 188



LOW LAWSON, LOW GRADE, N = 165

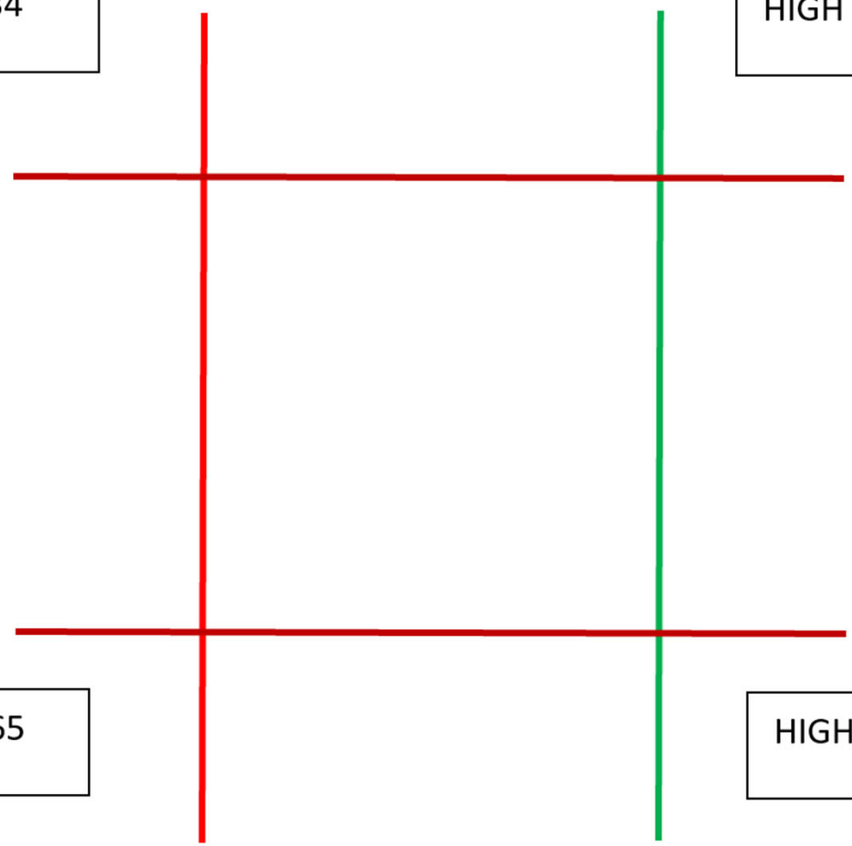
LAWSON PRETEST VS. GRADES, 20 CLASSES COMBINED



LAWSON PRETEST VS. GRADES, 20 CLASSES COMBINED

LOW LAWSON, HIGH GRADE, N = 34

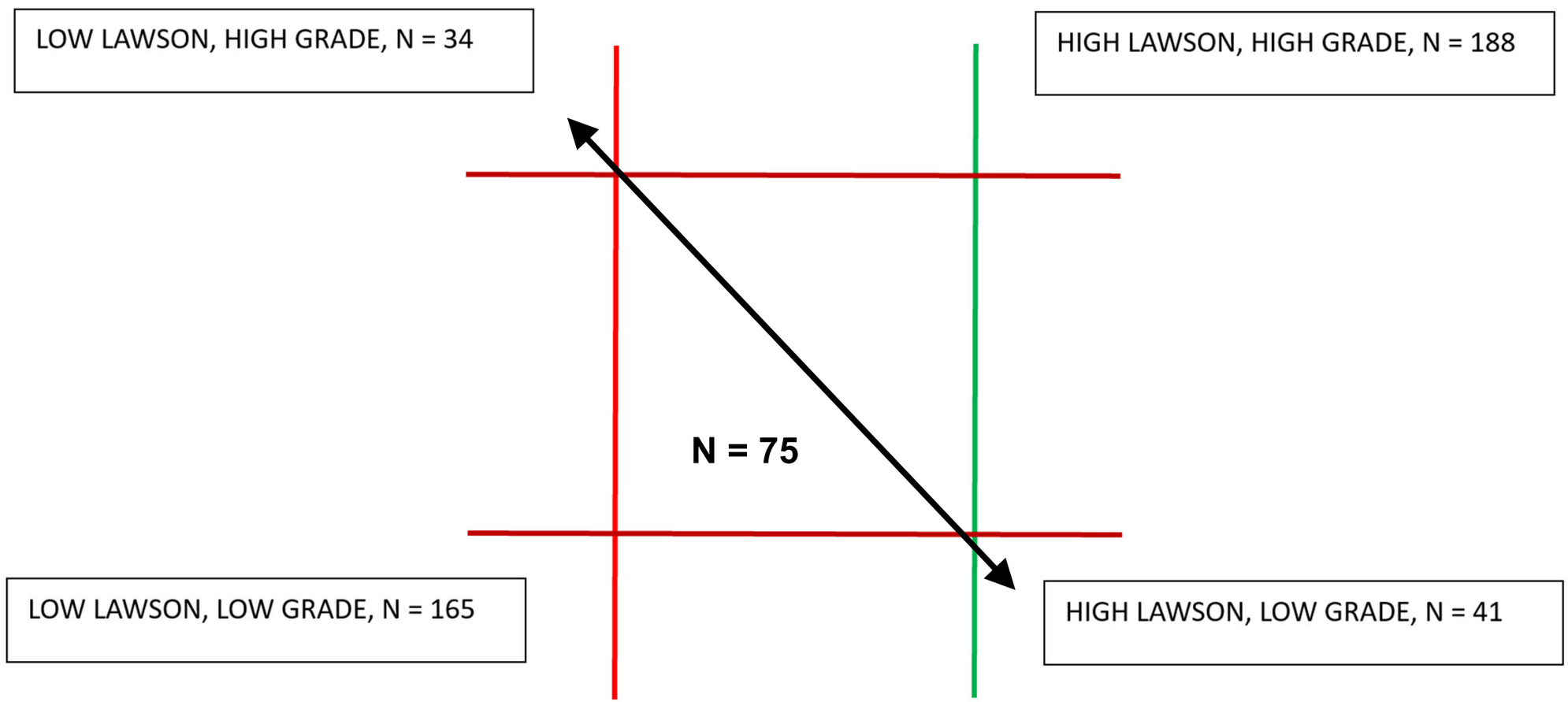
HIGH LAWSON, HIGH GRADE, N = 188



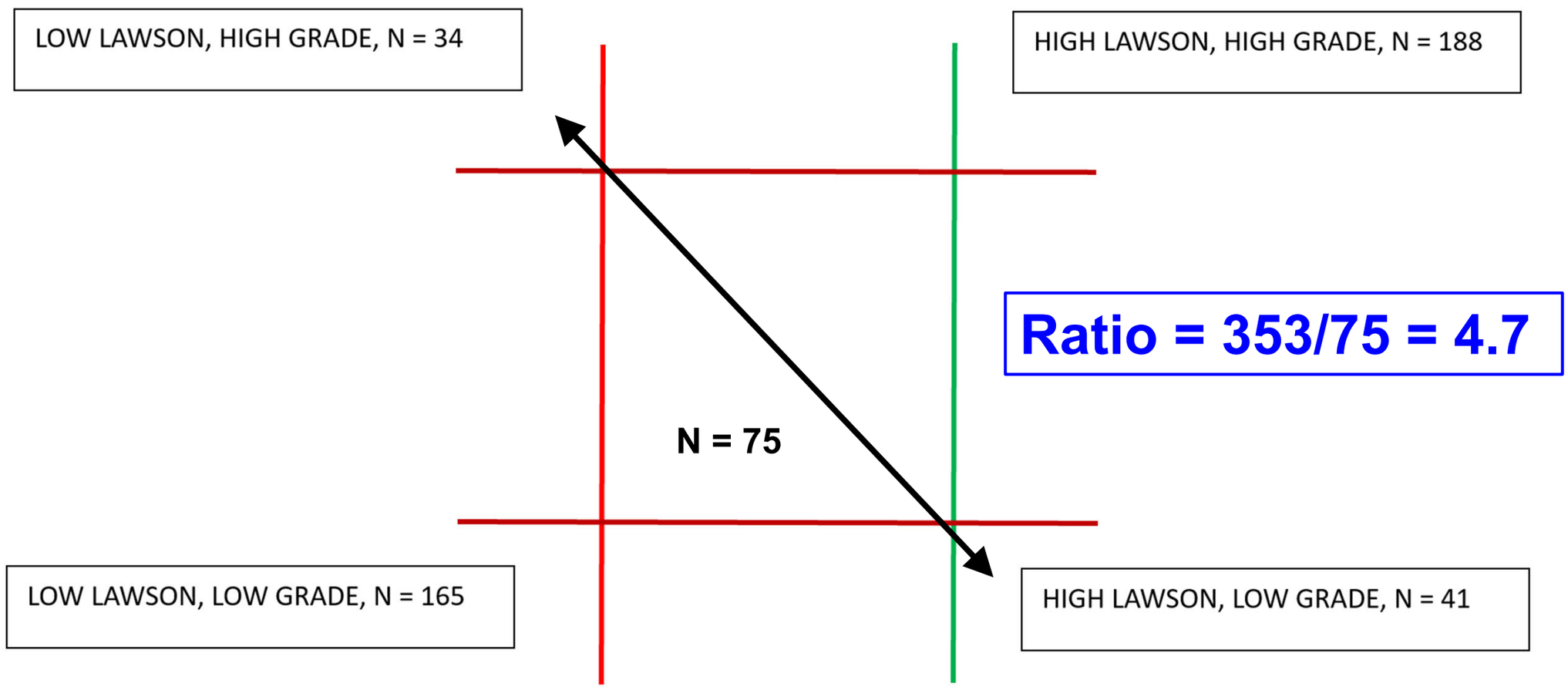
LOW LAWSON, LOW GRADE, N = 165

HIGH LAWSON, LOW GRADE, N = 41

LAWSON PRETEST VS. GRADES, 20 CLASSES COMBINED



LAWSON PRETEST VS. GRADES, 20 CLASSES COMBINED



Alternative to Regression Analysis

- Stratify sample into “high” and “low” scorers on pretest measure #1 (e.g, FCI), then separate each group further into high and low scorers on pretest measure #2 (e.g, Lawson test).
  - We already know that the measure #1 groups differ in grade probabilities
- Compare high/low grade probabilities to see whether pretest measure #2 offers *additional* predictive power regarding grade probabilities

Further Analysis of Alg-1 CU sample (*N* = 466)

		Probability of top-quartile grade	Probability of bottom-quartile grade
Top-Quartile on FCI Pretest	Top-half on Lawson pretest	60%	15%
	Bottom-half on Lawson pretest	26%	26%
	Ratio	2.3	1.8
Bottom-Quartile on FCI Pretest	Top-half on Lawson pretest	23%	15%
	Bottom-half on Lawson pretest	0%	26%
	Ratio	--	1.8

Even within a sample separated into high and low FCI pretest scores, Lawson pretest score was an additional reliable predictor of high/low grades.

Important Note

- Motivational factors can also be highly influential, in some cases overcoming the “disadvantages” revealed by low pretest scores.

Summary

- Numerous factors influence students' physics course performance
- Previous preparation in calculational skill, reasoning, and physics concept knowledge are significant predictors of course grades
- Our results are consistent with findings reported by:
  - L. Ding, PRPER **10,** 023101 (2014)]
  - Salehi et al., PRPER **15**, 020114 (2019)
  - Stewart et al., PRPER **17**, 010107 (2021)