

A black and white photograph of a desk. In the upper left, a white coffee cup filled with dark coffee sits on a matching saucer with a spoon. To the right, a silver pen lies diagonally. In the lower right, a pair of round-rimmed glasses rests on a piece of crumpled paper. The background is a light-colored surface with several small, rectangular labels or stickers scattered around.

Do the "write" Thing:

Bolstering Student Comprehension
in Introductory Statistics Classes

Bernard L. Dillard
JSM 2016

△

A black and white photograph of a desk, identical to the one above. It features a white coffee cup with dark coffee on a saucer with a spoon, a silver pen, a pair of round-rimmed glasses on crumpled paper, and several small labels on a light-colored surface.

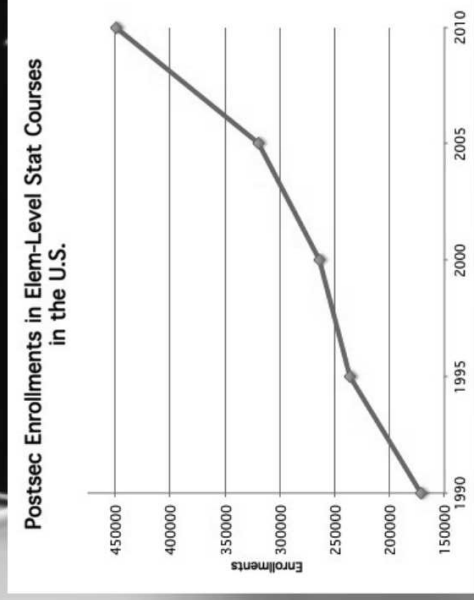
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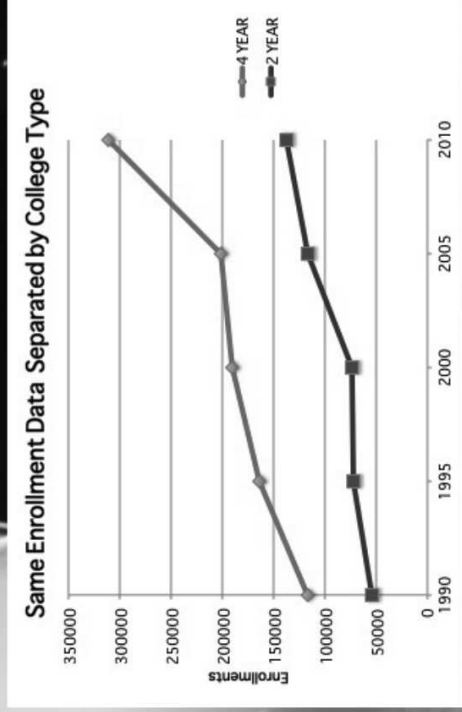
PostSecondary Enrollment Trends

Intro Stat Courses:
1990-2010
(Conference Board of
the Mathematical
Sciences)



By Institution Type

2 Yr VS 4 Yr:
1990-2010
(CBMS)



Rob Santos, ASA Vice President

"We Have Some Serious Explaining to Do"
AmStat News, July 2016



› **Yet, students of statistics are not uniformly afforded the opportunity to acquire and practice communication skills, especially to nonstatistical audiences such as the general public. If we wish to 'promote the practice and profession of statistics,' we should be able to speak to different audiences in terms they understand - be they fellow colleagues, scientists from other field, policy makers and government officials, the media, students, or even the public."**

ASA Guidelines for Undergrad Programs (2014)

The Role of Communication in Statistics

- › "Strong communication skills key!"
- › "Communicate results concisely and effectively"
- › "These include technical writing, presentation skills, ..."

ASA
American Statistical Association
11 Dupont Circle, N.W.
Washington, D.C. 20036
Phone: 202-336-7100
http://www.amstat.org



Guidelines for Assessment and Instruction in Statistics
Education (GAISE) College Report
(Revised, 2016)

Recommendations for Teaching Introductory
Statistics Courses

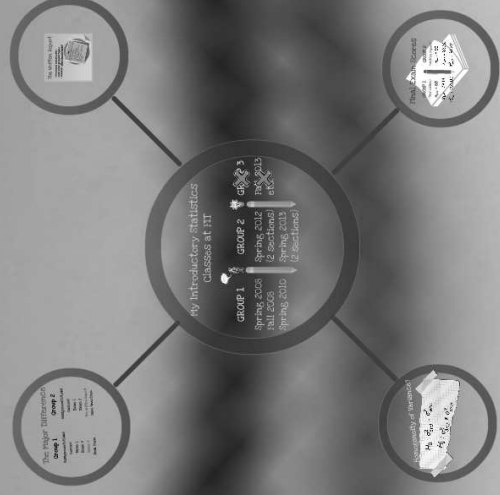
- › "Teach Statistical Thinking"
- › "Foster Active Learning"
- › "Integrate Real Data with a Context"
- › "Use Assessments to Improve Learning"

How Do We Measure Writing's Impact on
Content Mastery?

- › Writing Projects
 - › The Use of Rubrics
 - › Modeling by Instructor
- › Subject Mastery
 - › Students' Informal Self-Analysis of Process
 - › Quantitative Measures of Course Satisfaction
 - › No Real Objective Measures



Skewed to the "write"



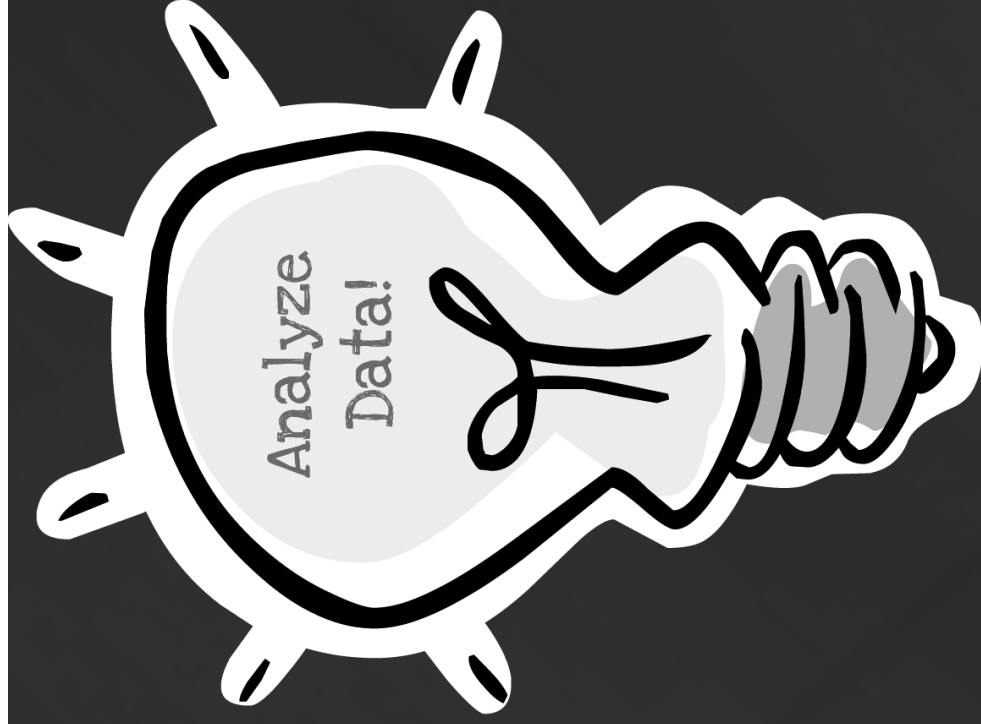
My Introductory Statistics Classes at FIT





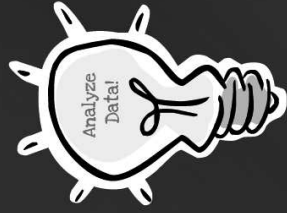
My Introductory Statistics
Classes at FIT

 GROUP 1		 GROUP 2		 GRX 3
Spring 2008 Fall 2008 Spring 2010		Spring 2012 (2 sections) Spring 2013 (2 sections)		Fall 2013 et X



My Introductory Statistics Classes at FIT

-  **GROUP 1**
Spring 2008
Fall 2008
Spring 2010
-  **GROUP 2**
Spring 2012
(2 Sections)
Spring 2013
(2 Sections)
-  **GRP 3**
Fall 2013
etc.



GRP 3

Fall 2013
etc.

The Major Difference

Group 1

Assignments/Labs

Quizzes

Exam 1

Exam 2

Exam 3

Final Exam

Group 2

Assignments/Labs

Quizzes

Exam 1

Exam 2

The Written Report

Same Final Exam

The Written Report

- › Introduced mid-semester
- › Instructor presents topics
- › Rubrics: <http://goo.gl/QzbbhJN>

Papers Must Cover One of the
Following Topics:

- Hypothesis Testing
- Difference of Two Means
- One-Way ANOVA
- Simple Linear Regression
- Chi Square

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Final Exam Scores

GROUP 1

(3rd exam)

$$n_{3rd} = 68$$

$$\bar{X}_{3rd} = 79.19$$

$$s_{3rd}^2 = 153.02$$

GROUP 2

(written report)

$$n_{writ} = 93$$

$$\bar{X}_{writ} = 83.32$$

$$s_{writ}^2 = 91.29$$

Homogeneity of Variance?

$$H_0: \sigma_{3rd}^2 = \sigma_{writ}^2$$

$$H_1: \sigma_{3rd}^2 \neq \sigma_{writ}^2$$

Folded-Form F Test

$$> F' = \frac{s_{3rd}^2}{s_{writ}^2} = \frac{153.02}{91.29} \approx 1.676$$

$$> F_{V_{3rd}, V_{writ}, 1-\frac{\alpha}{2}} = F_{67, 92, 0.975} = 1.55$$

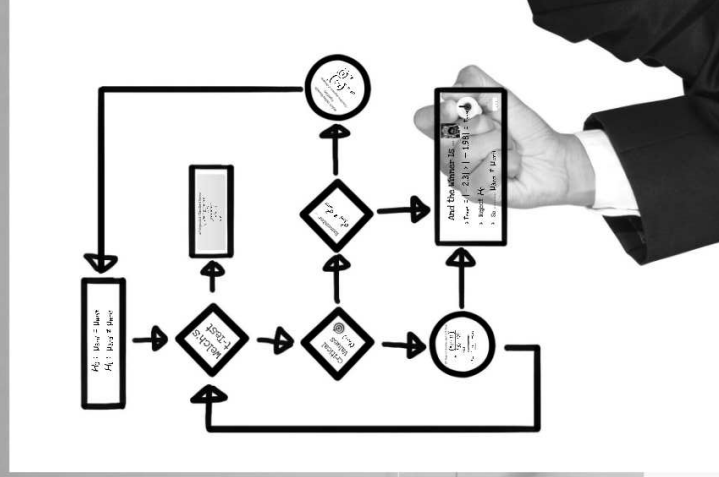
$$> F' > F_{V_{3rd}, V_{writ}, 1-\frac{\alpha}{2}}$$

> **Reject H_0**

$$\text{So, } \sigma_{3rd}^2 \neq \sigma_{writ}^2$$

So, $\sigma_{3rd}^2 \neq \sigma_{writ}^2$

Compare Differences Between 2 Means



Are Final
Exam Scores
(Virtually)
the Same?

$$H_0 : \mu_{3rd} = \mu_{writ}$$

$$H_1 : \mu_{3rd} \neq \mu_{writ}$$



welch's
t-Test

w/ Unpooled Standard Error

$$\begin{aligned} t_{\text{test}} &= \frac{(\bar{X}_{3\text{rd}} - \bar{X}_{\text{writ}}) - (\mu_{3\text{rd}} - \mu_{\text{writ}})}{\sqrt{\frac{s_{3\text{rd}}^2}{n_{3\text{rd}}} + \frac{s_{\text{writ}}^2}{n_{\text{writ}}}}} \\ &= \frac{(79.19 - 83.32) - 0}{\sqrt{\frac{153.02}{68} + \frac{91.29}{93}}} \\ &\approx -2.3 \end{aligned}$$

Critical Values

(t_{crit})



Remember ...

$$\sigma_{3rd}^2 \neq \sigma_{writ}^2$$

Welch-Satterthwaite
Equation

› Effective degrees of freedom

$$df' = \frac{\left(\sum_i \frac{s_i^2}{n_i} \right)^2}{\sum_i \frac{\left(\frac{s_i^2}{n_i} \right)^2}{n_i - 1}}$$

Eff Degr of Freedom and Crit Value

$$\text{df}' = \frac{\left(\frac{153.02}{68} + \frac{91.29}{93} \right)^2}{\left(\frac{153.02}{68} \right)^2 + \left(\frac{91.29}{93} \right)^2}$$

$$\approx 121$$



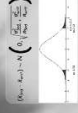
$$t_{crit} = t_{\alpha=0.05,121} \approx \pm 1.98$$

(2-Sided)

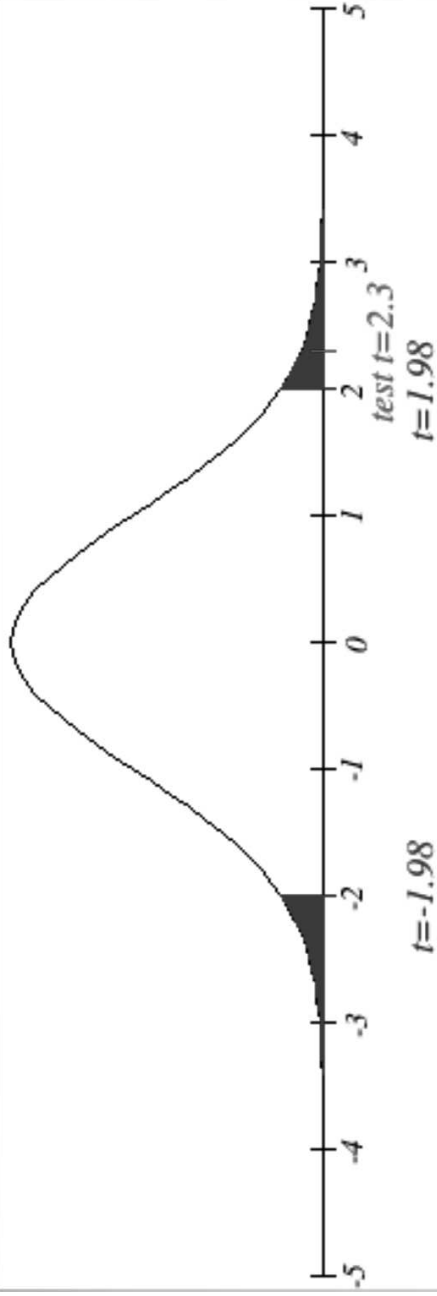


And the winner IS ...

- › $t_{test} = |-2.3| > |\pm 1.98| = t_{crit}$!
- › Reject H_0
- › So $\mu_{3rd} \neq \mu_{writ}$



$$(\bar{X}_{3rd} - \bar{X}_{writ}) \sim N \left(0, \sqrt{\frac{\sigma_{3rd}^2}{n_{3rd}} + \frac{\sigma_{writ}^2}{n_{writ}}} \right)$$



Final Thoughts!

Hmm! Significantly higher scores on same final when writing report involved

Maybe I Became A Better Instructor Over Time (nested?): But data shows no gradual increase in scores over time; even took a break

I Know! I Know! No causal relationship

Future challenge: Evaluate criteria gauging mastery via writing

Let's chat!



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