Do the "Write" Thing: Bolstering Student Comprehension in Introductory Statistics Classes

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JSM 2016
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 fields, 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, ..."
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

GROUP 1
Spring 2008
Fall 2008
Spring 2010

GROUP 2
Spring 2012
(2 sections)
Spring 2013
(2 sections)

GROUP 3
Fall 2013
	etc.
Try out Short, written reports!
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/QzbhjN

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)

\[
n_{3rd} = 68
\]

\[
\bar{x}_{3rd} = 79.19
\]

\[
\sigma^2_{3rd} = 153.02
\]

GROUP 2
(written report)

\[
n_{writ} = 93
\]

\[
\bar{x}_{writ} = 83.32
\]

\[
\sigma^2_{writ} = 91.29
\]
Homogeneity of Variance?

\[ H_0 : \sigma^2_{3rd} = \sigma^2_{writ} \]

\[ H_1 : \sigma^2_{3rd} \neq \sigma^2_{writ} \]

Folded-Form F Test

\[ F' = \frac{s^2_{3rd}}{s^2_{writ}} = \frac{153.02}{91.29} \approx 1.676 \]

\[ F_{v_{3rd}, v_{writ}, 1-\frac{a}{2}} = F_{67,92,0.975} = 1.55 \]

\[ F' > F_{v_{3rd}, v_{writ}, 1-\frac{a}{2}} \]

\[ \text{Reject } H_0 \quad \text{So, } \sigma^2_{3rd} \neq \sigma^2_{writ} \]
So, $\sigma_{3rd}^2 \neq \sigma_{writ}^2$

Compare Differences Between 2 Means

Are Final Exam Scores (Virtually) the Same?
$H_0: \mu_{3rd} = \mu_{4th}$
$H_1: \mu_{3rd} \neq \mu_{4th}$

Welch's t-Test
w/ Unpooled Standard Error

\[ t_{test} = \frac{(\bar{x}_{3rd} - \bar{x}_{writ}) - (\mu_{3rd} - \mu_{writ})}{\sqrt{\frac{\sigma^2_{3rd}}{n_{3rd}} + \frac{\sigma^2_{writ}}{n_{writ}}}} \]

\[ = \frac{(79.19 - 83.32) - 0}{\sqrt{\frac{153.02}{68} + \frac{91.29}{93}}} \]

\[ \approx -2.3 \]
Remember ...

\[ \sigma^2_{3rd} \neq \sigma^2_{writ} \]

Welch-Satterthwaite Equation

- Effective degrees of freedom

\[ df' = \frac{ \left( \sum_i \frac{s_i^2}{n_i} \right)^2 }{ \sum_i \left( \frac{s_i^2}{n_i} \right)^2 \frac{1}{n_i - 1} } \]
Eff Degr of Freedom and Crit Value

\[ df' = \left( \frac{153.02 + 91.29}{93} \right)^2 \frac{68}{68-1} + \left( \frac{91.29}{93} \right)^2 \frac{68}{68-1} \]

\[ \approx 121 \]

\[ t_{crit} = t_{a=0.05,121} \approx \pm 1.98 \]

And the winner is...

\[ t_{test} = -2.3 < |\pm 1.98| = t_{crit} \]

\[ H_0 \text{ is rejected.} \]

So...
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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