Mixing It Up:

The Impact of Resequencing Topics in an Undergraduate Introductory Statistics Course

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Introductory Statistics Courses (General)

Typical Characteristics

- Required Course
- First (*and Last*) Statistics Course
- Limited Mathematical Prerequisites
- Common Goals (Rumsey, 2002)
  - Statistical Literacy
  - Future Researcher

Previous Calls to Action

- 1992 Cobb Report
- Guidelines for Assessment and Instruction in Statistics Education (GAISE)
  - Endorsed by American Statistical Association (ASA)
  - 2005 and 2016

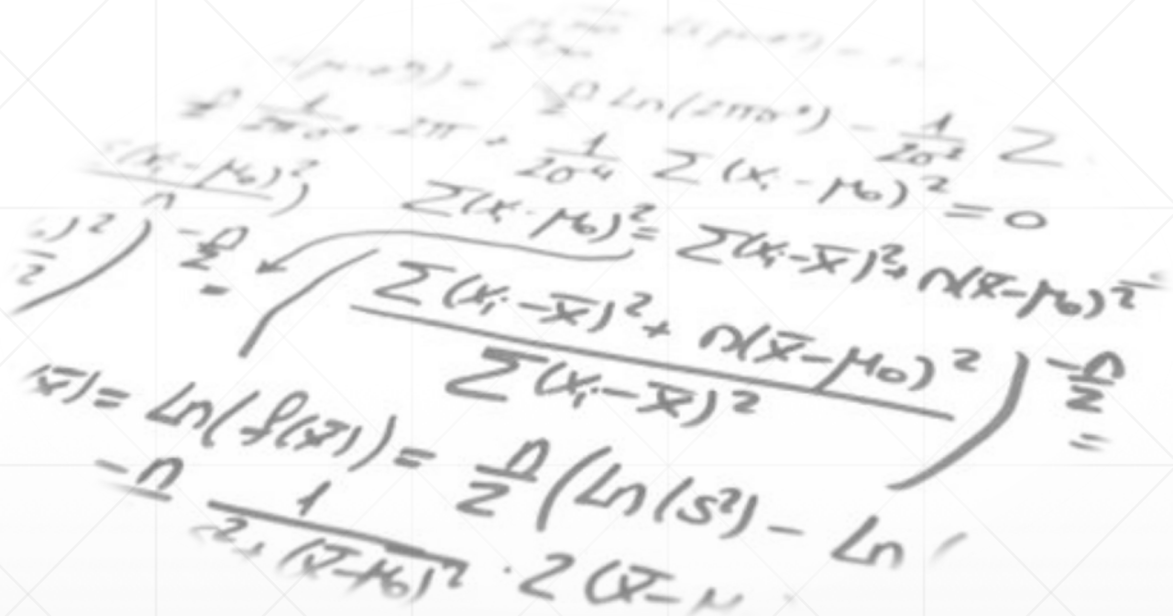
Introductory Statistics Courses (General)

Despite Previous Calls to Action

- There was little to no evidence of changes in course content or pedagogy as late as the 2010’s (Hedges & Harkness, 2017)
- Even technology use appears to be lacking at various institutions
  - Recommendations made for ‘technology deprived’ classrooms in the revised GAISE report (2016) are actually still commonplace in many classrooms
- Failure rates can exceed 40% (Lunsford & Poplin, 2011)

Principles of Statistics (STAT 2303)

- Required Course
- College Algebra Prerequisite
- Prior Structure
  - Arithmetic Heavy
  - Distribution Tables
  - ≈ 35-40% Failure Rate
- Some Previous Efforts at Change
  - Technology Integration
  - ≈ 30-35% Failure Rate



“To what extent do statistics teachers…

consider the learner as well as the discipline?”

- Hedges & Harkness, 2017, p. 353

Content Resequencing

Literature Review

- Posner & Strike (1976)
  - No 'Best' Sequence
  - Framework for Curriculum and Content Sequencing
  - Sequence Content
    - Learner
    - Learning Process
- Morrison et al. (2011)
  - Break from Textbook Sequence
  - Focus on the Learner Leads to Learning
- Malone et al. (2010)
  - Traditional Textbook Sequence:
    - Moves from Easy/Familiar to Difficult
    - Creates a Statistical Inference Roadblock
    - Does Not Follow Scientific Process

Content Resequencing

Literature Review

- Chance & Rossman (2001)
  - No ‘Best’ Sequence
  - However, Six Points of Agreement:

1. Data production issues warrant serious attention
2. Fundamental ideas should be introduced early and revisited often
3. Distractions should be minimized to allow students to focus on fundamental issues
4. Common elements of analysis that arise in different situations should be emphasized
5. Simulations are the best way to study randomness
6. Understanding sampling distributions is critical for understanding concepts of inference

- Malone et al. (2010)
  - Four Principles when Developing Alternative Sequences:

    1. More closely mimic what a scientist/statistician does
    2. Get to statistical inference earlier in the semester
    3. Follow what we know from learning theory
       (i.e., teach a complete process repeatedly in various settings for greater retention)
    4. Teach just enough probability to get by

  - Two Alternative Sequence Models:
    - Winona State University (WSU)
    - Grand Valley State University (GVSU)
    - Different Yet Markedly Similar

Content Resequencing

Literature Review

University of Arkansas (UA) Sequence Models

Comparison of Previous/Traditional Sequencing and Current Sequencing

Previous/Traditional Sequence	Current Sequence
I. Introduction II. Data Collection III. Exploring Data a. Visualizing Data b. Summarizing Data IV. Probability V. Sampling Distributions VI. Estimating Population Parameters a. Confidence Intervals (One Proportion) b. Confidence Intervals (One Mean) c. Confidence Intervals (One Standard Deviation) VII. Hypothesis Testing a. One Proportion b. One Mean c. One Standard Deviation VIII. Linear Correlation and Regression a. Linear Correlation b. Simple Linear Regression IX. Advanced Topics (Time Permitting) a. Confidence Intervals (Two Independent Proportions) b. Confidence Intervals (Two Independent and Dependent Means) c. Hypothesis Testing (Two Independent Proportions) d. Hypothesis Testing (Two Independent and Dependent Means) e. Chi-Square Tests X. Topics *Not* Covered Previously a. One Way ANOVA with Tukey Test b. Two Way ANOVA c. Residual Analysis d. Shapiro Wilk Test for Normality e. Multiple Linear Regression f. Logistic Regression	I. Introduction II. Probability III. Proportions (Categorical Data) a. Confidence Intervals (One Proportion) b. Hypothesis Testing (One Proportion) c. Confidence Intervals (Two Independent Proportions) d. Hypothesis Testing (Two Independent Proportions) IV. Means (Quantitative Data) a. Confidence Intervals (One Mean) b. Hypothesis Testing (One Mean) c. Confidence Intervals (Two Independent and Dependent Means) d. Hypothesis Testing (Two Independent and Dependent Means) e. One Way ANOVA with Tukey Test f. Two Way ANOVA V. Bivariate Data a. Linear Correlation b. Simple Linear Regression c. Residual Analysis d. Shapiro Wilk Test for Normality e. Multiple Linear Regression VI. Advanced Topics (Time Permitting) a. Chi-Square Tests b. Logistic Regression *Note*: In the current sequence, certain topics that traditionally were taught as stand-alone units are now taught just in time. These concepts (e.g., data collection, exploring data, and sampling distributions) are taught multiple times throughout the course where appropriate. *Additional Note*: Simulation (which is fundamental to many instructors of undergraduate introductory statistics) was not mandated but was incorporated into the course at the discretion of each individual instructor.

Development of the Revised University of Arkansas (UA) Sequence Model

- Backward Design
- Mixture of Learning-Related and Concept-Related Sequencing
- Result: Statistical Inference Encountered Early
  - Time for Learning
  - Time for Feedback
  - Mimics the Scientific Process
  - Data Based Projects Very Natural

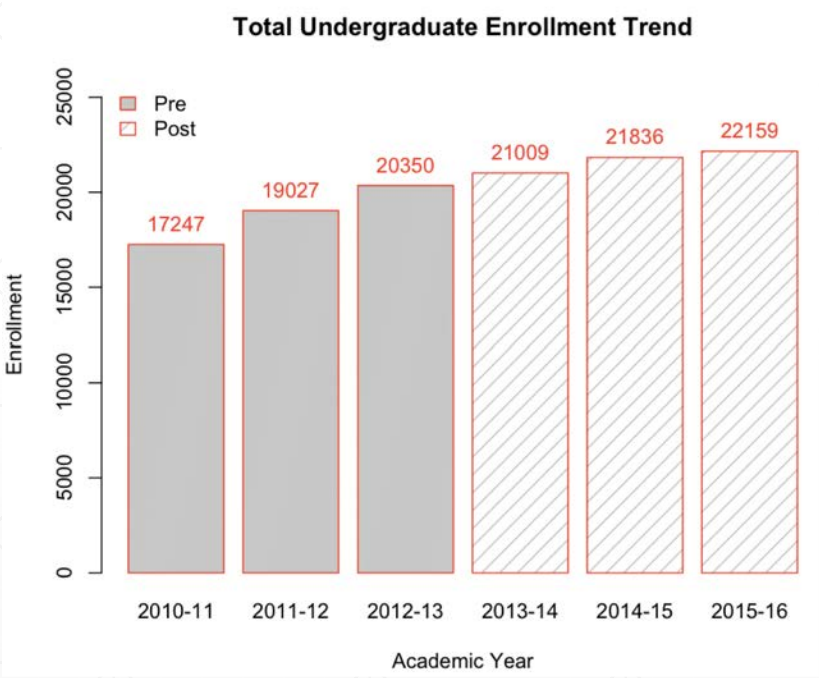
- Must Have for Buy-In:
  - Creation of Standalone Materials (apart from but utilizing the textbook)

Evaluation

- Outcomes of Interest
  - Success, Learning, Perception
- Samples
  - Pre-Intervention: 1406 Students
    - Five Semesters (2011 - 2013)
  - Post-Intervention: 3606 Students
    - Six Semesters (2013 - 2016)

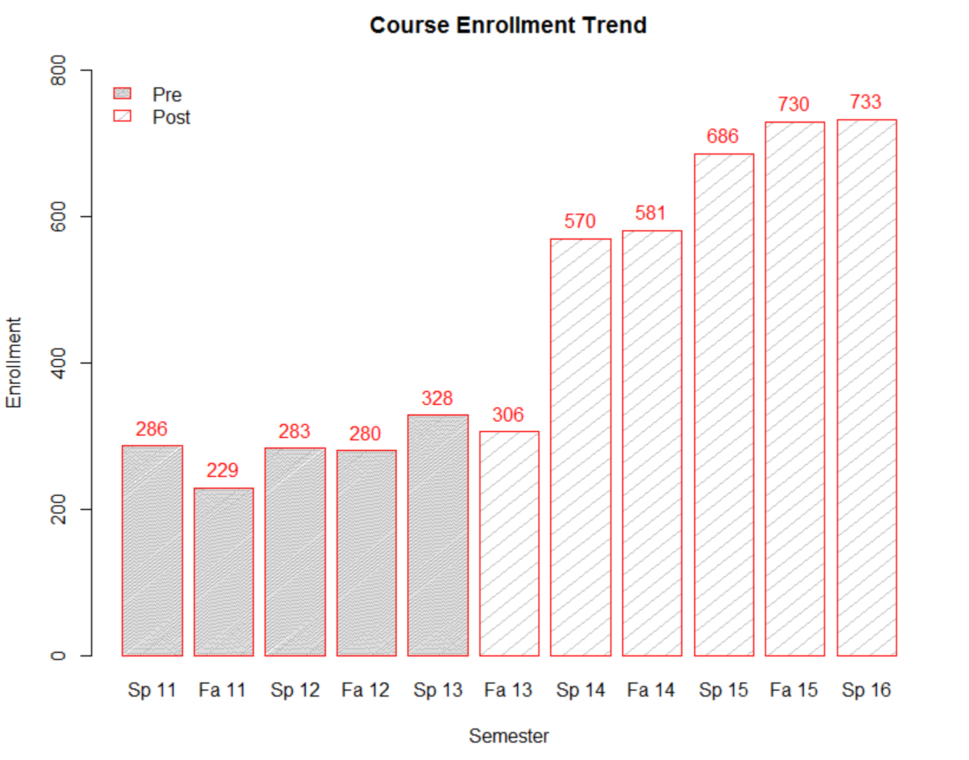
- Data Collection
  - Retrospective, Convenience Sample
  - Aggregate Pass/Fail Data
  - Individual Item Level Exam Response Data
  - Individual Course Evaluation Response and Comment Data

Evaluation



	Academic Year					
	2010-11	***2011-12***	***2012-13***	***2013-14***	***2014-15***	***2015-16***
Total Undergraduate Enrollment	N = 17247	N = 19027	N = 20350	N = 21009	N = 21836	N = 22159
ACT Score Mean (SD)	25.8 (3.7)	25.7 (3.6)	25.8 (3.5)	25.8 (3.5)	25.9 (3.6)	25.9 (3.5)
Sex (%)						
Female	48.4	49.0	50.1	50.7	51.7	52.2
Male	51.6	51.0	49.9	49.3	48.3	47.8
Academic Level (%)						
Freshman	30.2	31.4	29.9	27.0	27.3	28.5
Sophomore	20.3	21.7	22.2	22.8	21.1	20.8
Junior	20.8	19.5	21.1	21.8	22.1	21.4
Senior	28.7	27.4	26.8	28.5	29.5	29.3
Race (%)						
African American	4.8	5.0	5.1	4.9	5.0	4.8
Asian	2.5	2.6	2.6	2.4	2.5	2.5
Caucasian	80.5	79.7	78.9	78.4	77.2	76.7
Hispanic	4.5	5.0	5.7	6.4	6.9	7.5
Other	7.6	7.7	7.7	8.0	8.5	8.6
Home Residence (%)						
Arkansas	67.8	64.6	61.9	59.2	57.2	55.4
Missouri	4.7	5.3	5.8	6.3	6.4	6.3
Texas	13.3	15.3	17.3	18.8	19.9	21.7
Other	14.2	14.8	15.0	15.7	16.5	16.6
College (%)						
Agriculture	8.7	8.3	8.6	8.6	8.4	8.3
Architecture	2.8	2.5	2.2	1.6	1.8	1.8
Arts & Sciences	37.4	37.5	36.2	33.8	33.0	30.2
Education & Health	19.7	19.5	20.0	21.1	20.7	20.8
Engineering	13.4	14.0	14.6	15.3	15.6	16.3
Business	17.9	18.2	18.4	19.6	20.4	22.6

Evaluation



	Group	
	Pre-Implementation	***Post-Implementation***
Total Course Enrollment	N = 1406	N = 3606
ACT Score Mean (SD)	25.1 (3.9)	25.1 (3.7)
Sex (%)		
Female	59.2	66.5
Male	40.8	33.5
Academic Level (%)		
Freshman	13.9	16.3
Sophomore	29.3	34.9
Junior	26.6	28.7
Senior	30.1	20.1
College (%)		
Agriculture	14.7	9.2
Architecture	0.9	0.2
Arts & Sciences	44.0	47.7
Education & Health	32.1	34.8
Engineering	2.1	3.0
Business	6.1	5.2

- Student Success:
  - Odds of Success are **2** Times Greater
- Student Learning:
  - More Likely to ***Correctly*** Answer Inferential Questions
  - Significantly ***Higher*** Final Exam Scores
- Student Perception:
  - More Likely to ***Highly*** Rate the Course
  - Significant ***Improvements*** in Student Comments Across Four Emergent Themes:
    - Course Organization
    - Course Value
    - Course Technology Use
    - Connections Between Mathematics and Statistics

Evaluation

Key Takeaways

Questions?

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Thank you!

Cited Works

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