

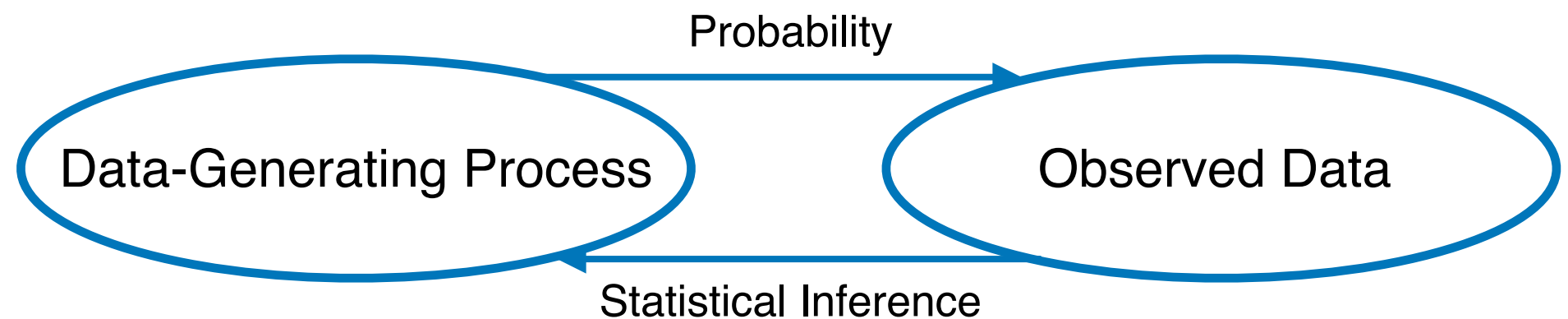


# Performing Meaningful Assessment in a Modernized Mathematical Statistics Course Sequence

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- borrowed from *All of Statistics* (Wasserman 2004)



**Assessment in Modern Mathematical Statistics**

*P. E. Freeman - May 2022*

Teaching Statistics Group: <http://www.stat.cmu.edu/teachstat/>

**eCOTS 2022**





## The Mathematical Statistics Course Sequence

- The calculus-based course sequence traditionally features a semester of probability followed by a semester of statistical inference, and is often taught in an “old school” manner that is heavy on lecturing and light on computing (if computing is utilized at all).
- A traditional mode of assessment in this sequence is to give pencil-and-paper “solve these mathematical problems” tests.

There are two (related) issues here...

How do we modernize  
the math stat course sequence?

and

How do we do it in such  
a way as to improve students'  
conceptual understanding?

- In this breakout session, we will concentrate on the second question, by discussing ways of assessing student learning that go beyond “solve the problem” tests.

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## As For the First Question...

“We will not solve this problem easily; no one really knows what to do.”

- Carl Morris (2003)

We will use this opportunity to advertise our upcoming JSM session (with Ayona Chatterjee, Randall Pruim, and Jonathan Wells):

492 \* ! Thu, 8/11/2022, 8:30 AM - 10:20 AM

Why Probability, Then Statistics When it Can Be Probability, for Statistics? New Approaches for Teaching Mathematical Statistics — Invited Papers

Section on Statistics and Data Science Education, Section on Statistical Learning and Data Science, International Association for Statistical Education

Organizer(s): Peter E. Freeman, Carnegie Mellon University

Chair(s): TBD TBD, TBD

8:35 AM Utilizing Spiral Learning to Enhance Conceptual Retention in Mathematical Statistics  
Peter E. Freeman, Carnegie Mellon University

8:55 AM Three-Course Dinner or Thanksgiving Feast? Putting the Pieces Together in a Modern Math/Stat Sequence  
Randall Pruim, Calvin University

9:15 AM Teaching Probabability Theory in the Inverted Style  
Jonathan Wells, Reed College

9:35 AM Calcu Less - Compute More: Rethinking traditional pathways for increasing access to Data Science  
Ayona Chatterjee, Cal State Univ East Bay

9:55 AM Cutting Through the Theory: Emphasizing and Assessing Conceptual Understanding in Mathematical Statistics  
Erin Blankenship, University of Nebraska-Lincoln; Jennifer Green, Michigan State University

10:15 AM Floor Discussion

(We do know what to do...but it's really context dependent!)

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## Case Study: the CMU Math Stat Sequence

- The current sequence, with course numbers 36-225 and 36-226, utilizes the “old school” approach. These are the last CMU statistics courses awaiting modernization.
- Anecdotal evidence suggests that many students who pass through these courses do not adequately attain/retain conceptual understanding: they see many concepts only once (like estimation) and they fixate on mathematical details.
- In Fall 2022 and Spring 2023, we will pilot a new course sequence that utilizes a spiral-learning approach that intertwines probability and statistical inference and provides repeated exposure to basic concepts. (And utilizes computers for, e.g., visualization and simulation!)
- Two questions immediately spring to mind:

Are these changes “enough”?      and      Will the changes “work”?

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## Case Study: Are These Changes “Enough”?

- Restated: is it enough to implement a spiral-learning approach while keeping traditional modes of student assessment (i.e., assessment used to assign class grades) in place: mathematically based homework, quizzes, and exams?
- We would argue no. (Or else we wouldn't be here today!)
- The situation is neatly summed up in this title:

### Teacher's Corner

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#### I Hear, I Forget. I Do, I Understand: A Modified Moore-Method Mathematical Statistics Course

Nicholas J. HORTON

<https://www.tandfonline.com/doi/full/10.1080/00031305.2013.849207>

- Students must work with the conceptual details, not just see them stated (even if the statements are made repeatedly).



## Case Study: Are These Changes “Enough”?

- The goal of the remainder of this session is to introduce, discuss, and develop(!) alternate modes of low- and high-stakes assessments that could help improve student outcomes in your math stat courses.

### Fostering Conceptual Understanding in Mathematical Statistics

Jennifer L. GREEN and Erin E. BLANKENSHIP

<https://www.tandfonline.com/doi/full/10.1080/00031305.2015.1069759>

*Your student assessment senseis.*

- But before we move into this phase of the presentation, I will mention...

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## Case Study: Will the Changes “Work”?

- At CMU, we will have an opportunity to determine the efficacy of the new math stat sequence, since both the new and old sequences will be taught side-by-side.
- We will utilize think-aloud interviews of students who have completed either the new or the old sequence to determine whether our new approaches do indeed facilitate greater conceptual understanding.

Research Article

### Think-Aloud Interviews: A Tool for Exploring Student Statistical Reasoning

Alex Reinhart , Ciaran Evans , Amanda Luby, Josue Orellana , Mikaela Meyer , Jerzy Wieczorek 

Accepted author version posted online: 22 Apr 2022, Published online: 13 May 2022

<https://www.tandfonline.com/doi/full/10.1080/26939169.2022.2063209>

See also <https://www.causeweb.org/cause/ecots/ecots20/posters/2-02>

This is not about the mathematical details, per se... it is about tracking student thought processes to see where conceptual issues lie.

Example:

You are given  $y_1, y_2, \dots, y_n$  i.i.d. samples from the following density:

$$f(y | \theta) = \begin{cases} \left(\frac{2y}{\theta}\right) \exp\left(-\frac{y^2}{\theta}\right) & y > 0 \\ 0 & \text{otherwise} \end{cases}$$

Find  $\hat{\theta}_{MLE}$ .

Start time (mm:ss):

Identifying relevant variable

- ☐ Applied random variable rules to constant
- ☐ Wrong variable for int./diff./expectation
- ☐ Translated words to wrong expression
- ☐ Couldn't match variables in two expressions
- ☐ Conditioned on wrong variable
- ☐ \_\_\_\_\_

Rules?

- ☐ Can't identify relevant rule
- ☐ Wrong probability formula
- ☐ \_\_\_\_\_

Math errors?

- ☐ Basic arithmetic
- ☐ Integration/differentiation
- ☐ Variable substitution
- ☐ Definition of MGF
- ☐ Definition of Fisher information
- ☐ Interpretation of table
- ☐ \_\_\_\_\_

End time (mm:ss):

Result: ☐ Correct ☐ Incorrect ☐ Guessed

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