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

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CAUSE/JSDSE webinar series

Welcome!

Host and Moderator:
Leigh Johnson
Capital University

What's new in the journal?

Teaching Reproducibility

Article

Collaborative Writing Workflows in the Data-Driven Classroom: A Conversation Starter ›

Sara Stoudt

Published online: 23 Jun 2022

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Research Articles

Article

A Multi-Level Analysis of the Effects of Statistics Anxiety/Attitudes on Trajectories of Exam Scores ›

Kelly Rhea MacArthur PhD & Jonathan B. Santo PhD

Accepted author version posted online: 27 Jun 2022

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July CAUSE/JSDSE Webinar

Integrating Data Science Ethics Into an Undergraduate Major: A Case Study

Ben Baumer, Randi L Garcia, Albert Y. Kim, Katherine Kinnaird, & Miles Q. Ott
Smith College

July 19, 2022 at 1:30 PM EDT

Consortium for the Advancement of Undergraduate Statistics Education

Recordings available of the keynote talks!

https://causeweb.org/cause/ecots/ecots22

CAUSE Research Reading Group

CAUSE Research is starting a reading group to read through the 14 articles mentioned in Rob Gould's talk "The Modern Student . . . Is Younger" eCOTS 2022 invited talk.

General Format of the reading group:

- Will meet for one hour to talk about the meeting's paper.
- We will meet on the first and third Wednesday during the summer. (Exception: Since the first Wednesday in July falls during the week of Independence day (July 4th), we will meet on June 29th instead.) Participants will discuss a time for the fall semester.
- You don't have to attend each time to participate in the reading group.

If you have any questions, please contact Megan Mocko (Megan.Mocko@warrington.ufl.edu)

July 29 Paper

Wild, C. J., Pfannkuch, M., Regan, M., & Horton, N. J. (2011). Towards more accessible conceptions of statistical inference. Journal of the Royal Statistical Society: Series A (Statistics in Society), 174(2), 247-295. https://doi.org/10.1111/j.1467-985X.2010.00678.x

Alex Reinhart

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Alex Reinhart is an Assistant Teaching Professor of Statistics and Data Science at Carnegie Mellon University. His work has ranged from spatiotemporal data analysis to large-scale COVID surveys, and he is interested in statistical pedagogy and course design.

Ciaran Evans

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Ciaran Evans is an Assistant Professor of Statistics at Wake Forest University. He is interested in statistical education and pedagogy, and enjoys collaborating with other educators on teaching and research.

Amanda Luby

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Amanda Luby is an Assistant Professor of Statistics at Swarthmore College. She works on statistical methods for understanding complex decision-making, and is also interested in statistics education research and practice.

Think-Aloud Interviews

A Tool for Exploring Student Statistical Reasoning

Alex Reinhart, Ciaran Evans, and Amanda Luby
on behalf of the TeachStat Group
https://www.stat.cmu.edu/teachstat/

We need tools to understand student reasoning

- To improve our own teaching
- To design interventions and new curricula
- To write assessments and concept inventories
- To understand how *experts* approach problems

There are a range of tools available

1. Anecdotal observation of homework submissions, tests, lab activities
2. Discussions with students in office hours, class activities, labs
3. Standardized assessments and concept inventories
4. Interviews or focus groups with students
5. Think-aloud interviews

Think-aloud interviews provide unique information

- Developed in cognitive science by Ericsson and Simon
- Students complete a task while narrating their thinking aloud *with no feedback*
- An unfiltered view of student thinking

Often used to:

- Design and revise concept inventories (such as RPASS, AIRS, BLIS, REALI)
- Study expert practice (e.g. Lovett, 2001)
- Identify student misconceptions

Used for research, not for grading

Think-alouds fit into your research process

Think-aloud process: step by step

1. Prepare a research plan
    - Think-aloud interviews should match the study goal
    - Possible uses for think-alouds include
        - Developing concept inventories
        - Studying expert practice
        - Studying misconceptions
        - Improving course design
    - IRB approval (or exemption) may be necessary!

Think-aloud process: step by step

1. Prepare a research plan
2. Choose interview questions
    - Questions depend on the study goal
    - Questions should avoid memorization, and not be too easy or hard (Pressley and Afflerbach, 1995)
    - We drafted questions on core introductory statistics concepts

Think-aloud process: step by step

1. Prepare a research plan
2. Choose interview questions
3. Recruit participants
    - Crucial to avoid participants feeling judged/evaluated (Leighton 2013)
        - Interviewer (and recruiter) should be separate from the course
        - Clarify that no identifying information about participants will be shared with instructor
        - Repeat assurances at the beginning of the interview

Think-aloud process: step by step

1. Prepare a research plan
2. Choose interview questions
3. Recruit participants
4. Conduct interviews
    - Begin by welcoming participant and explaining the study and interview (Leighton 2017)
    - Give a think-aloud warm up (Leighton, 2017; Liu and Li, 2015)
    - Ask questions
    - Debrief and compensation

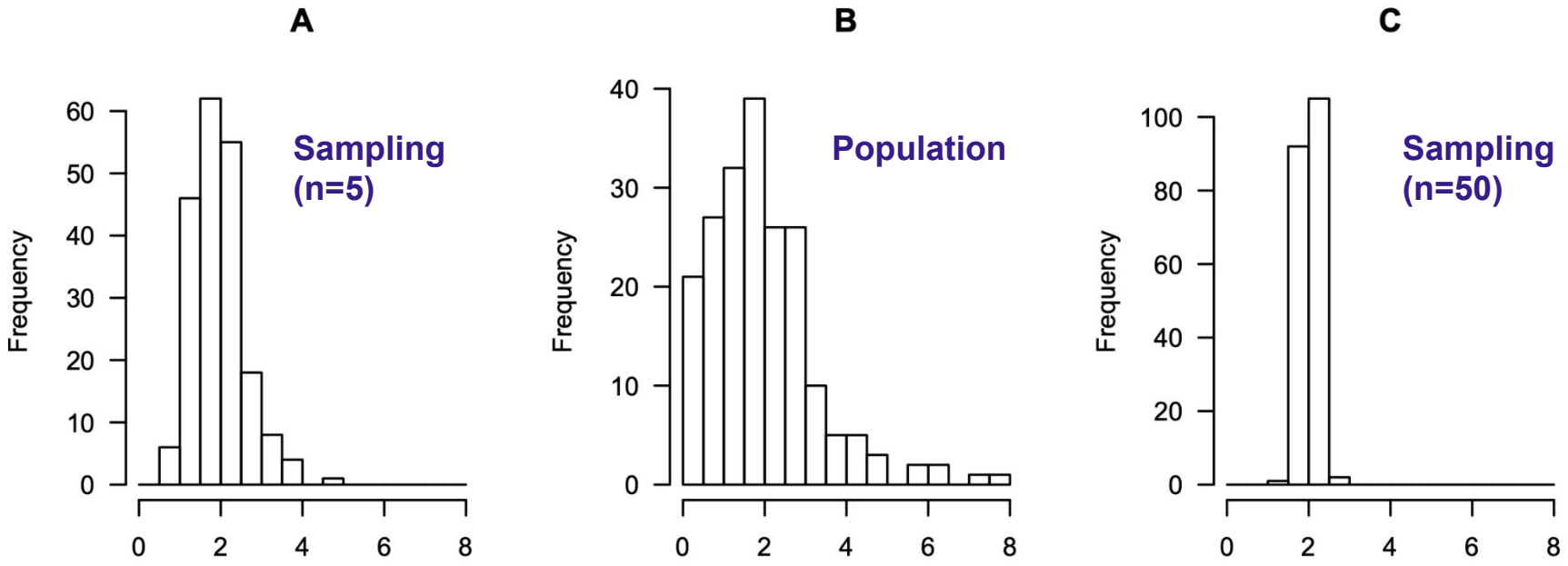
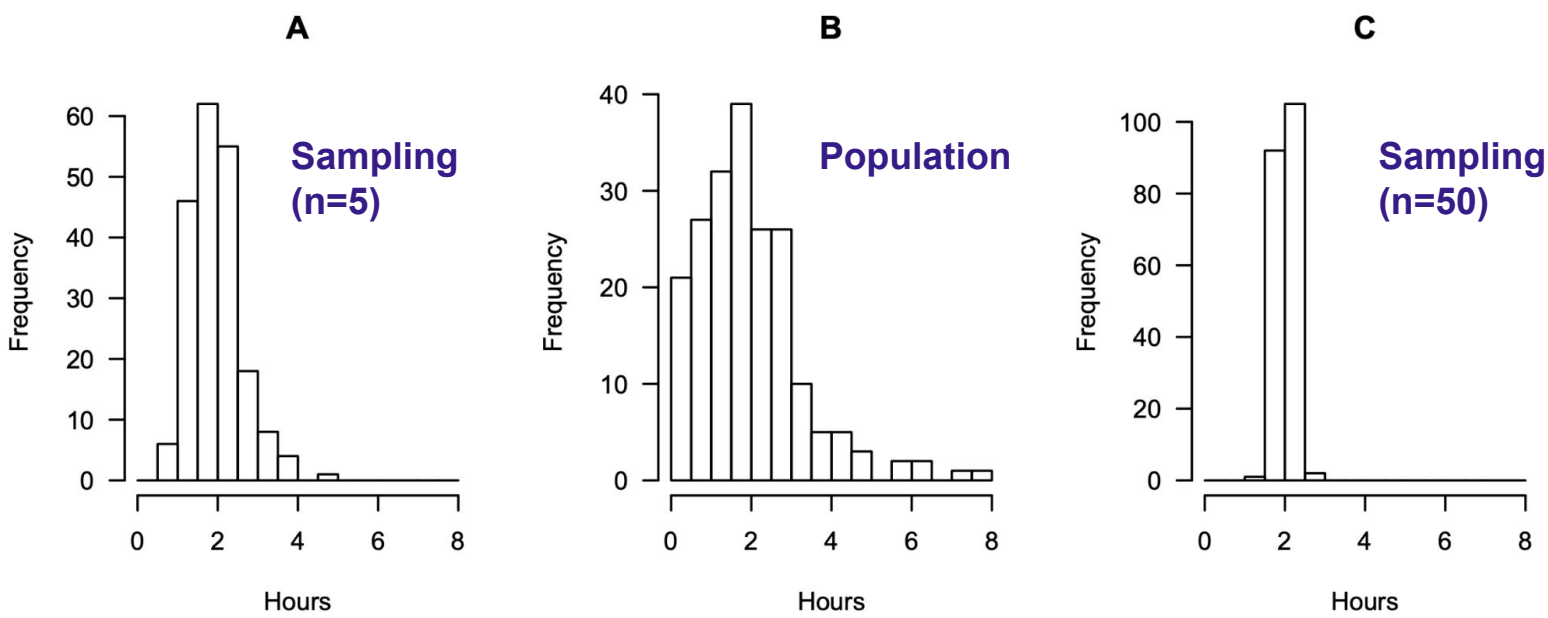


Fig. 1 (study-time, original version) To estimate the average number of daily hours that students study at a large public college, a researcher randomly samples some students, then calculates the average number of daily study hours for the sample. Pictured (in scrambled order) are three histograms: One of them represents the population distribution of number of hours studied; the other two are sampling distributions of the average number of hours studied $\overline{X}$, one for sample size $n=5$, and one for sample size $n=50$. Circle the most likely distribution for each description.

- Population distribution: A B C
- Sampling distribution for $n=5$: A B C
- Sampling distribution for $n=50$: A B C

All 9 think-aloud participants got it wrong, and only one reasoned about the variance



"Small *n* means few bars" → Matched smallest sample size to graph C (3 students)

"Population should be normally distributed" → Matched population to graph A (2 students)

Would students still get the question wrong if we explicitly state the sample size and remove statistical jargon?

(study-time, revised version) Jeri, Steve, and Cosma are conducting surveys of how many hours students study per day at a large public university.

Jeri talks to two hundred students, **one at a time**, and adds each student's answer to her histogram.

Steve talks to two hundred **groups of 5 students**. After asking each group of 5 students how much they study, Steve takes the **group's average** and adds it to his histogram.

Cosma talks to two hundred **groups of 50 students**. After asking each group of 50 students how much they study, Cosma takes the **group's average** and adds it to his histogram.

9 of 12 participants answered the new question correctly

- Five correctly referenced the normality or spread of means: “taking the average of a larger group should lead to the means being all bunched in one place”
- Three misread the question and thought Cosma had four groups of 50, and still confused the number of bars with the sample size
- One student who answered incorrectly matched Cosma’s larger groups of students with graph A because “it looks more normal”

Conclusion

- Think-alouds are valuable for exploring student understanding of statistics concepts *beyond* correct/incorrect
- Student responses helped us identify unexpected misconceptions
  - Additional examples in the paper
- We encourage the use of think-alouds by other statistics education researchers

Thank you

Alex Reinhart, Ciaran Evans, Amanda Luby, Josue Orellana, Mikaela Meyer, Jerzy Wieczorek, Peter Elliott, Philipp Burckhardt & Rebecca Nugent (2022): Think-Aloud Interviews: A Tool for Exploring Student Statistical Reasoning, *Journal of Statistics and Data Science Education*. (All references in presentation are listed in the paper)

See also: Ciaran Evans, Alex Reinhart, Philipp Burckhardt, Rebecca Nugent, & Gordon Weinberg (2020): Exploring how students reason about correlation and causation. eCOTS 2020 virtual poster.

Appendix

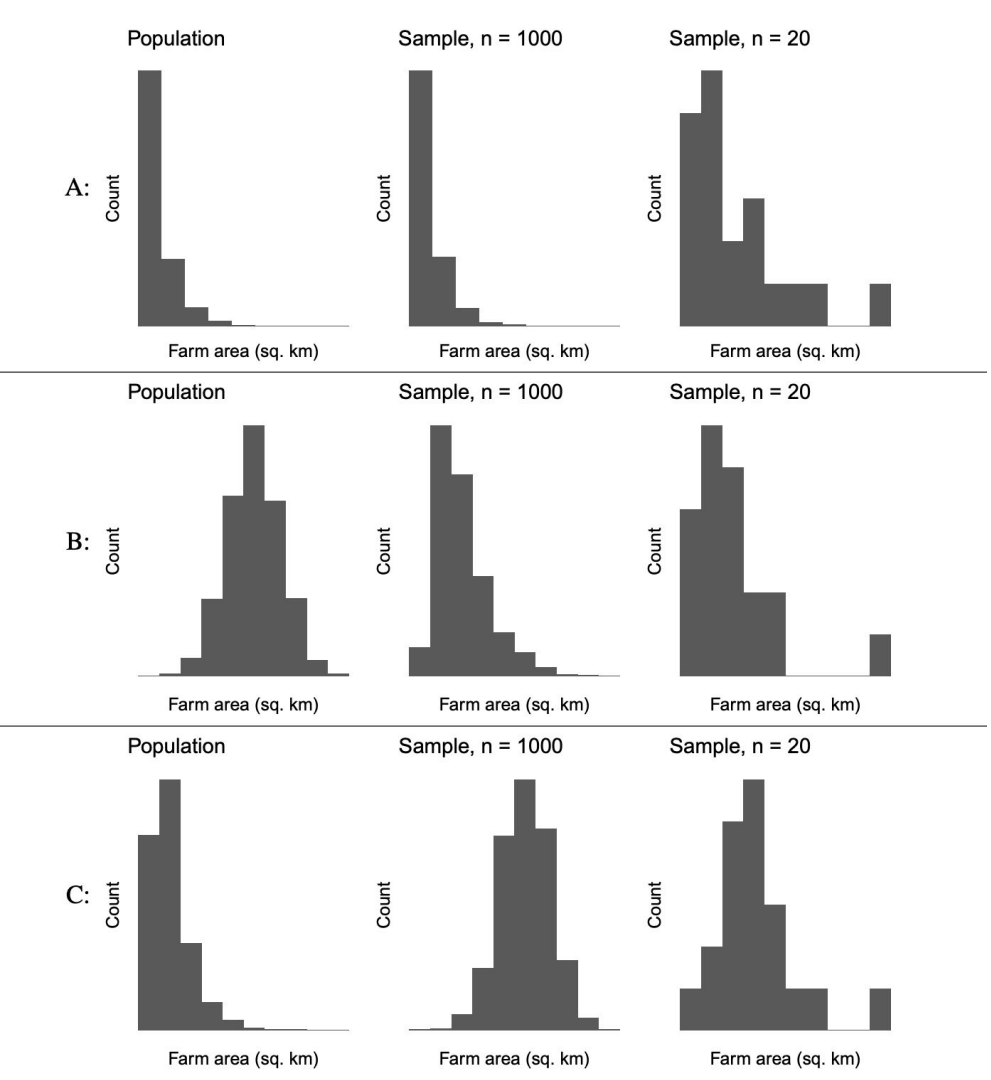
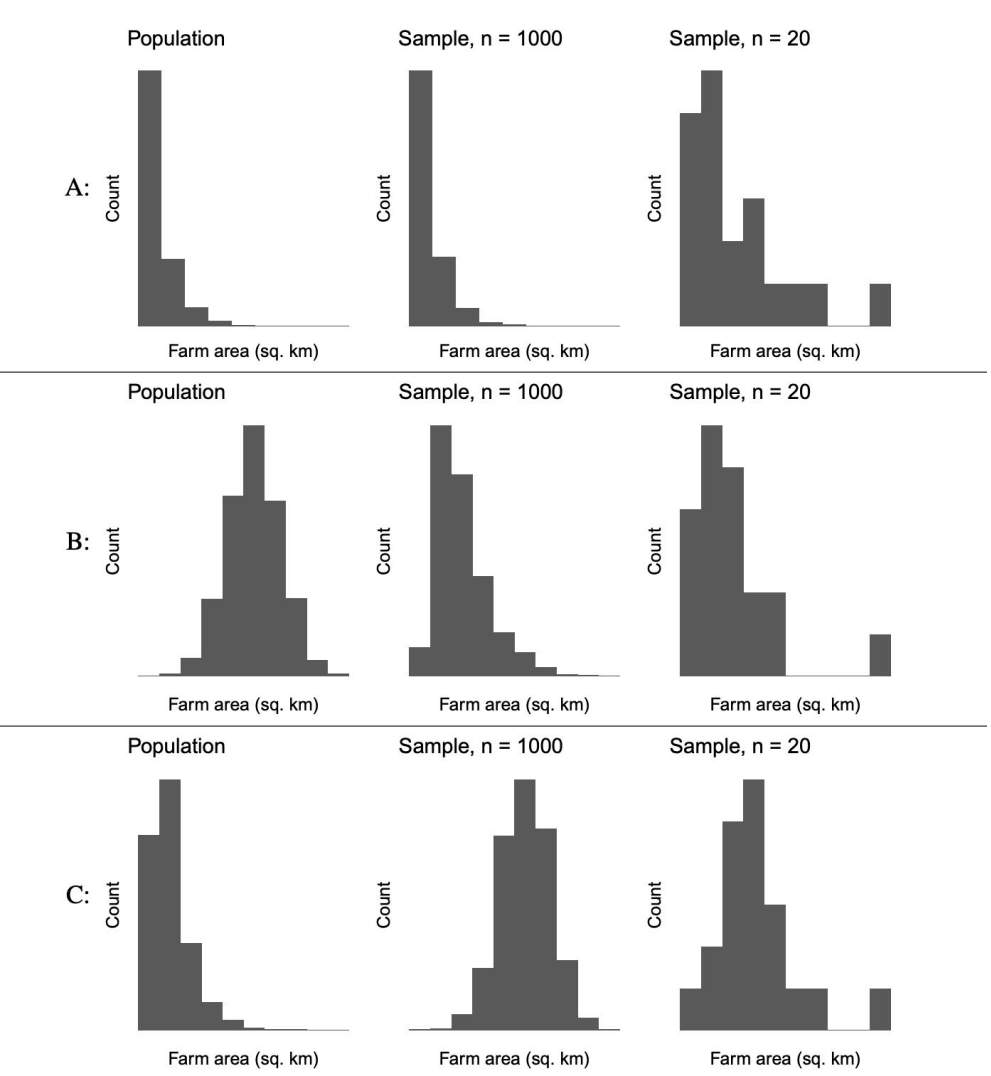


Fig. 2 (farm-areas) Farmer Brown collects data on the land area of farms in the United States (in square kilometers). By surveying her farming friends, she collects the area of every farm in the United States, and she makes a histogram of the population distribution of U.S. farm areas. She then takes two random samples from the population, of sizes n=1000 and $n = 20$, and plots histograms of the values in each sample. One of the rows below shows her three histograms. Using the **shape** of the histograms, choose the correct row.



Incorrect (3 students)

"With a larger sample size, there is less of a chance for data to vary" and this option has the most "centralized" population distribution

Incorrect (3 students)

"I'm assuming it's looking for a normal distribution, the greater the sample size", suggesting they were looking for normality that would be expected if these were *sampling* distributions