Working Backwards: Data Visualization Activities Designed to Promote Struggle

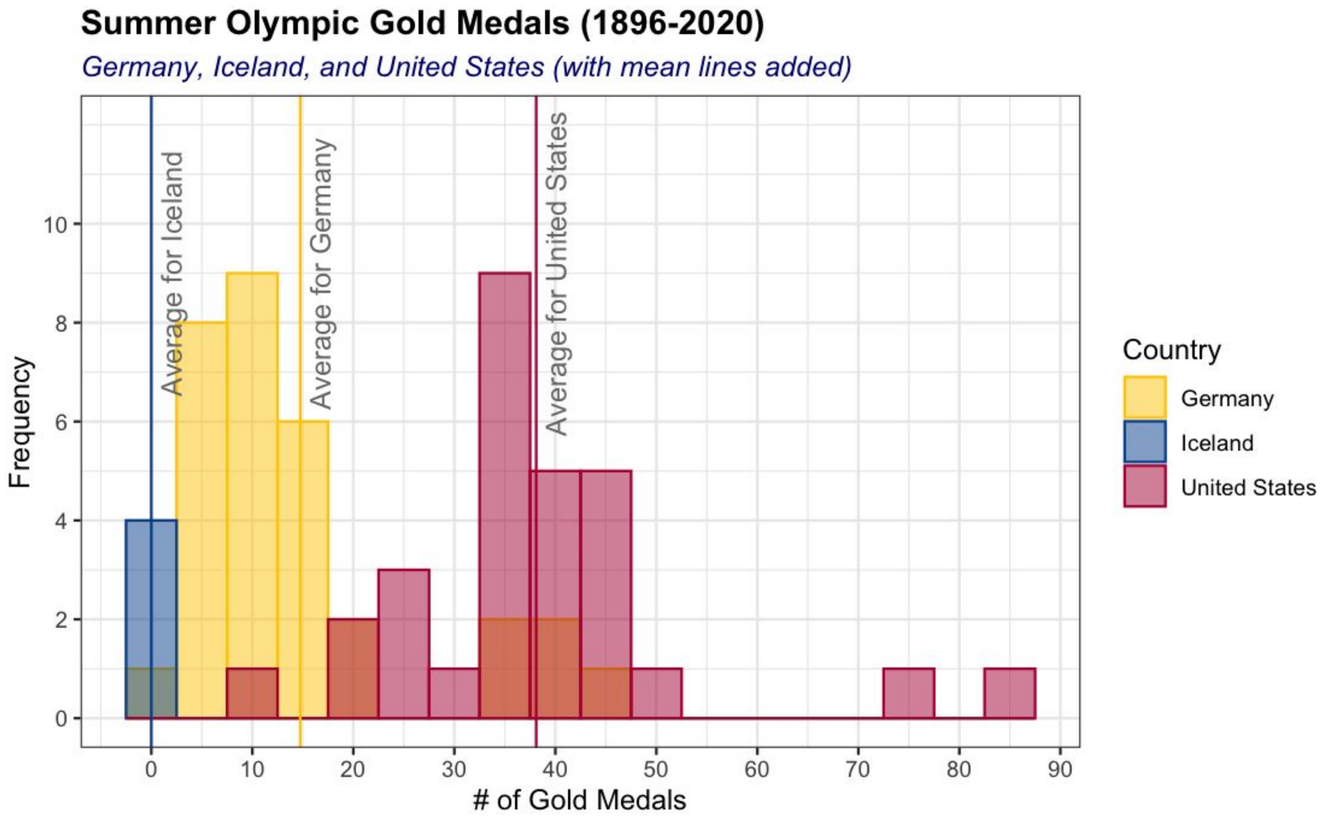
Lisinker, R., Carpenter, Z., Legacy, C.

Background

- Productive Failure (PF) is a learning design where students tackle open-ended, complex problems, often leading to initial "failure." before receiving direct instruction.
- PF activities do not provide students with any guidance, instead, questions are met with words of encouragement and students are told to keep trying

Implementation

- Introductory data visualization course using ggplot2 in RStudio
  - No prerequisites, fulfills a mathematical thinking requirement
  - Active learning, generally in groups of 3
- **Typical class activity:** Complete guided step-by-step activities where new features of graphs are introduced alongside code and examples
- **PF class activity:** Recreate detailed data visualizations with features they have and haven't seen before - without guidance.
  - Each plot has new aesthetic elements/features (e.g. changing title color, importing icons for scatter plot points).
  - End with a comparison of students' work, a "canonical solution," and a classroom discussion of major challenges, failures, and successes.



What's on the Recreate?

Students *should* know (i.e. explicitly taught or featured in previous class activities/assignments):

- Create a histogram
- Update binwidth
- Create multiple histograms using `fill = `
- Use `position = identity` instead of creating a stacked effect
- Update alpha value for opacity
- Update the title, axis labels, and subtitle texts
- Update tick marks for x-axis
- Add vertical lines using `geom_vline()`

Low-hanging fruit (adjacent to known elements):

- Change color of subtitle font
  - Shown how to change the title font color
- Color by a categorical variable
  - Used `color =` for a static color
- Update tick marks for y-axis
  - Provided with an instructional link for x-axis tick marks

Surprise features:

- Add limits to y-axis for all relevant tick marks to appear
- Add a label/annotation to the vertical lines
- Bold the title font
- Italicise the subtitle font
- Compute mean values within categories

Future data analysis will look at:

- **Videos** of whole-class pedagogy and **surveys** and **student interviews** to investigate class culture surrounding errors and longitudinal emotion measures (Carpenter, Z.)
- **Screen**, **audio**, and **video recordings** of students' PF activities, paired with **student artifacts** to explore students' (re-)creation skills and comprehension (Lisinker, R.)

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References

Kapur, M. (2008). Productive failure. Cognition and instruction, 26(3), 379-424.
Kapur, M., & Bielaczyc, K. (2012). Designing for productive failure. Journal of the Learning Sciences, 21(1), 45-83.