A Slippery Slope: How Introductory Statistics turns into Remedial Mathematics

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Background

Recent survey results reveal that many statistics GTAs would like to promote more student-centered, activity-driven approaches in their instruction, yet struggle to enact these practices (Justice, Zieffler, & Garfield, 2017). The uncertainty of facilitating open-ended tasks can be overwhelming for new statistics GTAs (Kaplan & Roland, 2018). In their work with mathematics GTAs, I investigate this phenomenon with statistics GTAs as I unpack barriers to the enactment of a constructivist and uniquely statistical pedagogy.

Instructors' decisions are deeply rooted in their conceptions of the discipline they teach (Speer, 2008), and the statistics literature describes several important statistical practices and dispositions needed to engage in statistical work. These would include things like skepticism, creativity, constructing explanations, and making judgments (e.g., Wild & Pfannkuch, 1999). Research also reveals that many statistics GTAs struggle with the concepts undergirding introductory statistics content (Noll, 2011; Green, 2010). I consider what practices and ideas the GTAs in this study shared about statistics and whether these understandings interacted with their instructional decisions.

1) What are the instructional visions of these four statistics GTAs?

2) What factors and experiences contribute to this vision, and what external influences shape their actual teaching practice?

Overview of Methods

I implemented a multiple case study design (Yin, 2009) to document the ongoing experiences, developing views, and eventual teaching practices of four first-year statistics GTAs. Each participant completed 6 interviews, 3 surveys, and 6 observations of their instruction (or access to their course site for those who were online instructors). The nature of a longitudinal study with various data sources allowed me to triangulate findings while also testing explanations through member checking.

Selected References

Green, J. L. (2010). Teaching highs and lows: Exploring university teaching assistants' experiences. *Statistics Education Research Journal*, *9*(2), 108-122.

Justice, N., Zieffler, A., & Garfield, J. (2017). Statistics graduate teaching assistants' beliefs, practices and preparation for teaching introductory statistics. *Statistics Education Research Journal*. *16*(1), 294-319.

Kaplan, J. J. & Roland, K. E. (2018). Improving capacity and quality of undergraduate statistics instruction through research-based TA training experiences. In M. A. Sorto, A. White, & L. Guyot (Eds.), *Looking back, looking forward. Proceedings of the Tenth International Conference on Teaching Statistics*. Voorburg, The Netherlands: International Statistical Institute.

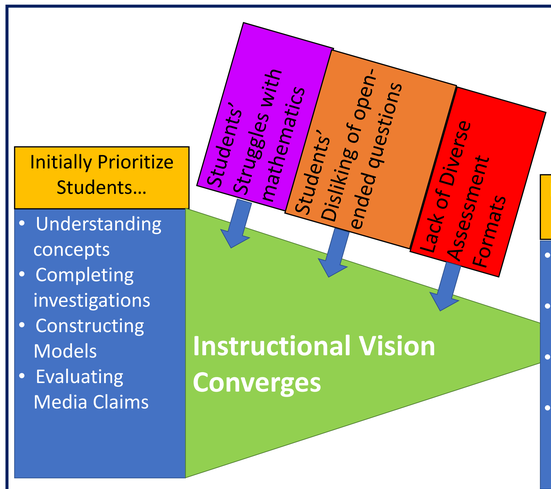
Noll, J. A. (2011). Graduate teaching assistants' statistical content knowledge of sampling. *Statistics Education Research Journal*, *10*(2), 48-74.

Wild, C., and Pfannkuch, M. (1999). Statistical thinking in empirical enquiry. *International Statistical Review*, *67*(3), 223– 265.

Abstract

Graduate Teaching Assistants (GTAs) play an important role in undergraduate statistics instruction, yet our field has little research-based evidence on effective training for this group. Insights from an initial interview and survey with four, first-year GTAs revealed that three of these GTAs wanted to prioritize goals related to statistical literacy and thinking in their introductory course. As recitation instructors, however, the GTAs began scaling back these instructional visions in their interviews as they documented (a) students' struggles with basic mathematics, (b) students' dislike for open-ended tasks, and (c) their own uncertainty regarding non-traditional forms of assessment. As became clear in later interviews, as well as analysis of their teaching, these new instructors delivered instruction that shied away from open-ended tasks and uniquely statistical questions, instead emphasizing computational mastery and procedural fluency. These findings offer implications for GTA and instructor training. New instructors may benefit from discussions about "productive struggle" and "formative assessment" that encourage them to let students grapple with tasks that may not have singular answers. Secondly, attention to parse statistical learning goals from mathematical goals may allow instructors to reassess what mathematical proficiency their students need.

Pedagogical Convergence



Li, Sahil, and Mindy all articulated a vision for teaching statistics that included many desirable pedagogical elements. However, external factors played a big role in constraining this vision from ever manifesting

1) The GTAs noted that many students struggled with calculations and mathematical notation. The GTAs felt that students needed to be able to calculate things by hand to demonstrate understanding.
2) The GTAs also noted that students got flustered when a task or question was too open-ended. GTAs saw their role as feeding answers to students and felt uncomfortable watching students struggle.
3) Finally, the GTAs were unsure how to assess students outside a quiz/exam format. Thus, all questions ultimately had to fit this model, despite many statistical practices being difficult to assess this way.

GTA Training

Statistical Investigations

Not all new GTAs have well-developed conceptions of statistics, in part due to limited disciplinary experiences prior to the program. The incorporation of data investigations may be beneficial for new GTAs like Kathy by demonstrating important components of statistical problem-solving that go beyond calculations.

Rigorous Tasks (beyond calculations)

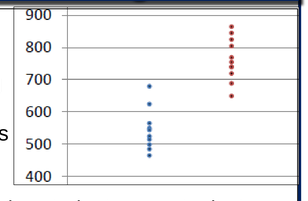
Even with these well-developed conceptions, lack of appropriate resources and instructional examples to draw from may leave GTAs to compartmentalize introductory statistics from higher-level work, or view difficult calculations as a necessity. GTAs need examples of open-ended tasks that engage students in disciplinary practices and concepts, rather than viewing procedural fluency as the gatekeeper to higher-order understanding.

Productive Struggle

All four GTAs were concerned to see students struggle, in part because they felt they were doing something wrong and needed to immediately provide the answer. Learning educational notions, such as productive struggle and rigor may benefit their pedagogical sense and ability to administer cognitively-demanding tasks.

Instructional Strategies

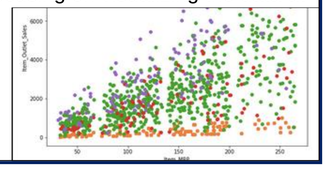
Informal Inferential Reasoning



Informal Inferential Reasoning (IIR) is a pedagogical approach that pushes students to informally compare groups before learning a formal method or test. Activities that give students opportunity to engage in IIR push them to understand concepts first, with calculations and procedures following as a secondary matter.

Exploratory Data Analysis

Exploratory Data Analysis (EDA) is described by many statisticians and data scientists as an important first step in the analytical process. By focusing on visualizing the data at hand and exploring summary statistics, students are pushed to think about the context and generate explanations for how variables relate.



Kathy

Disciplinary and Pedagogical Coherence around Procedures

- Struggled to differentiate mathematics and statistics
- Statistics and math courses primarily deal with problems where there's "a process and a right answer"
- Students need to learn "the basics"
- Valued questions with clear, singular answers
- Good statistics instructors explain things clearly and provide resources that help students find right answers

Li & Sahil

Disciplinary Compartmentalization

- Believed statistical work involved creativity—there are many valid ways to approach a statistical problem
- Viewed students as lacking basic mathematical knowledge
- Emphasized intro course that was rule-based because students would seem frustrated when there wasn't a rule to apply
- Sahil "didn't want to give students the impression that these rules can be changed" so students wouldn't be overwhelmed

Mindy

Disciplinary and Pedagogical Tension

- Mindy's data science internship provided a basis for her views about engaging in statistical work
- She described her mission as "helping [students] understand why they're doing statistics and not to be robots," but confessed that she didn't know how
- Mindy recognized students' struggles with math, but a deeper issue was the procedurally-focused nature of the instructional resources in the department.
- She began to question her own conceptions of statistics and began to wonder if the exploratory data analysis she was doing before was perhaps wrong.