Stirring the Curricular Pot Once Again

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A Look Back, Then Forward

Rethinking the Introductory Course

I had high hopes of a major upheaval in statistics education after George Cobb's 2005 USCOTS talk and paper (Cobb, 2007). I naively believed that statistics educators would find new insights for teaching statistical concepts as they integrated technology more routinely into their teaching. I believed that introductory students would embrace a randomization-based curriculum to deepen inferential understanding. I believed that teaching and learning randomization-based inference would promote statistical thinking and would be an impetus to transform our overall approach to introductory statistics education. It would just take some time.

What I see a decade later is that a dedicated minority of statistics educators embraced the development and teaching of randomization-based inference and simulation (e.g., Chance and Rossman, 2006; Lock, Lock, Morgan, Lock, and Lock, 2013; Tintle, Chance, Cobb, Rossman, Roy, Swanson, VanderStoep, 2015; West, 2009). However, the vast majority of statistics educators seem skeptical. Some teachers report having tried a randomization or simulation demonstration or two. Others inserted a few class activities as well. Such minor changes are not likely to produce a lasting, measureable change in students' inferential reasoning. And the research comparing learning outcomes from randomization-based courses to the normal-based status-quo has enough limitations and confounding factors that the skeptic can remain unconvinced.

Rethinking the Entire Undergraduate Curriculum

Having been a proponent of randomization-based methods, I was at first taken aback by Cobb's newest "shaking of his finger." I took a deep breath. I reread one of Cobb's recent papers (Cobb, 2011) and reminded myself that he has been calling for curricular change on a regular basis (Cobb, 2011, 2007, 2000, 1992; Cobb and Moore, 1997). He has proposed that we teach inference using the randomization test (Cobb, 2007) for some and start with statistical modeling for the more mathematically minded student (a la Kaplan, 2012). He seems to periodically stir the pot to challenge us to better teaching and learning of statistics. "We can advance the cause of statistics teaching and learning by identifying and questioning unexamined assumptions about what we do, why we do it, and when we do it" (Cobb, 2011, p. 31).

Cobb now asks statistics educators to take a more dramatic step, to think outside of our comfortable curricular box. Think creatively about how we can better prepare our students to wrangle the truth from data. Rethink our curriculum in order to make room for:

- algorithmic and computational techniques,
- data science methods,
- Bayesian inference, and an
- authentic research experience.

Cobb is challenging us to admit that not all probabilities are equiprobable; many statistical questions cannot be modeled with a known reference distribution; and all probabilities are conditional. And to do something about it!

One Alternate Path

At St. Olaf we have experimented with teaching topics outside the more traditional sequence (i.e., outside of z-tests, t-tests, multiple regression, logistic regression, etc.). Our intermediate course for social science research includes topics that students might encounter in graduate school (Lane-Getaz, 2012). The course is designed to meet the preparedness of students who have only taken our statistical literacy service course. The syllabus includes four weeks of ANOVA and ANCOVA methods (one-way, two-way and interaction), two weeks of measurement topics (scale development, reliability, validity, bias and discrimination) and six weeks of dimension reduction analyses: principal components analysis (PCA) and exploratory factor analysis (EFA). During the final three weeks students choose, develop and present an activity-based lesson to the class. After the inaugural course offering, one student wrote, her favorite aspect of the course was "learning PCA and EFA. I had never done anything like this before, and I was really excited to learn it because it is so applicable in psychology research! I think we learned it in a way that made it comprehensible at the undergraduate level" (Lane-Getaz, 2012).

Fall of 2015 is the third scheduled offering of the course. After reading Cobb's article, I ask "Was I bold enough?"

I am reminded of a bright student in Statistical Modeling, the foundational course for statistics concentrators. This student proposed to do his final project using decision tree classification. I was hesitant. The course topics were multiple and logistic regression. Besides, how would I evaluate his work? Despite my misgivings, his final presentation to the class was sound, easy to follow and quite extensive—including animated colorful graphics. Regretfully, his final exam was less than stellar. He hadn't attended to learning the intended course topics. To this day I feel that he deserved a better grade than he earned, mathematically. The student had followed his curiosity, taught himself a new procedure, and introduced the class to classification. The topic was an accessible, useful alternative to logistic regression for his dataset.

Online discussion of "Mere Renovation is Too Little Too Late: We Need to Rethink Our Undergraduate Curriculum From the Ground Up," by George Cobb, *The American Statistician*, 69. Sharon J. Lane-Getaz is Associate Professor, Department of Mathematics, Statistics and Computer Science and the Dept. of Education, St. Olaf College (E-mail: lanegeta@stolaf.edu).

This story points out how we, as statistics educators, need to join our students in the dance of curiosity and experiment. We need to let go of our fear of change and the unknown. We need to remind ourselves that teaching and learning is a never-ending process for the students and for us. If we get stuck in a rut of teaching the same things we learned, the same way we learned them, and assess the same way we always have, then we—and the field of statistics—will be left behind.

Cobb's Five Imperatives

With that in mind, I wish to applaud Cobb's five summative imperatives that might guide our re-thinking of undergraduate statistics curricula:

1. *Flatten the pre-requisites.* Mathematics prerequisites serve as a barrier to entry to non-mathematical but bright thinkers. Many of the students in our introductory level service course are good critical thinkers but are not well-prepared mathematically. Of these students, a small number do choose to take a second course in statistics, our intermediate level statistics course for social science research (Lane-Getaz, 2012.) These students have an avenue to deepen their statistical thinking and gain confidence in their statistical ability. The course is a step up for those who plan to attend graduate school in statistics or a related field.

2. *Embrace algorithmic/computational thinking.* My ambitious statistical modeling student serves as an example to me to be fearless. A logical, step-by-step, computational approach to a problem is valid when the data do not conform to our standard paradigm: (1) same data source, (2) row and column format, (3) probability model fits. Our data-driven society demands that we grapple with these new types of data and that we make this new content accessible to a broader array of student interests and needs (Horton, 2015). [Flashing back to my story and my new course, could I find a place in my new course for decision tree classification?]

3. *Seek depth.* In the tradeoff between depth and breadth, we teachers tend to cling to breadth. But students may better remember the deeper experiences. For example, we teach ANOVA designs and analysis using data that students have collected from a day of launching gummy bears (adapted from Cobb and Miao, 1998). The first day of class is dedicated to time-consuming data collection. It is well worth it. Students are actively engaged, rolling up their sleeves in teams, and discussing design issues to the degree they can, from day one. For homework they are asked to start organizing their data to compare launch distances for the various conditions. They are primed to learn two-way ANOVA, blocking, main effects and interaction. They remember.

4. *Exploit context.* As a mathematics undergraduate, I saw context as ancillary to the problem, even bothersome. Cobb (2015) reminds us "in applied data analysis context provides meaning." This statement is blatantly obvious to my social science students. In fact, they are more comfortable dealing with issues related to the context of our case studies than they are with the statistical issues. Students in our introductory level service course tend to take on big, controversial questions for their final class projects. They typically analyze data from the General Social Survey and Youth Risk Behavior Survey, among others. Recent topics explored relationships between: Gender, Alcohol and Depression; Mental Health, Drugs and Physical Activity; Racial Discrimination in Employment, and Drugs, Mental Health and Sexual Behavior. Context motivates.

5. *Teach through research.* Similarly, authentic research experiences motivate and teach students what statisticians really do. The expanded Center for Interdisciplinary Research (eCIR) has proved to be a great maturation ground for our statistics concentrators (Legler, Roback, Zieglar-Graham, Scott, Lane-Getaz, and Richey, 2010). The eCIR lab promotes creative approaches to data analysis, in collaboration with faculty from across the college. These research collaborations foster closer relationships among the eCIR fellows (our students), between the fellows and faculty, and among the faculty as well. Most importantly, the eCIR fellows are inspired to pursue additional statistical studies.

Conclusion

"For every action there is an equal and opposite reaction." If Newton's law applies, we can expect a big reaction to Cobb's call for curricular change. We need to temper this reaction and heed the call to rethink our content and our teaching. We need to promote the statistical thinking required to analyze today's data. The modern students sitting in our classrooms now have dramatically different data-related experiences than in years past (Gould, 2010). With the heightened expectations of the modern student, our traditional courses are sure to disappoint. Re-thinking the undergraduate curriculum is imperative. Cobb has laid out some essential ingredients for our consideration as we stir the curricular pot once again.

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