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Discussion: Making Progress in a Crowded Market

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In their wide-ranging, insightful and provocative paper, Ograjenšek & Gal (2016) restate and enunciate our shared goal to help motivate students to learn to use data to provide answers to real-world problems. They also provide specific suggestions about additional ways to create more opportunities for scaffolding and practice of qualitative thinking in our courses and curriculum. I commend them for this guidance—which is wholly consistent with the sentiments of many—including Brown & Kass (2009), the INGEnIOuS project, http://www.ingeniousmathstat.org and Cobb (2015). All suggest a broad definition of statistics, encourage efforts to ensure that statistics is a vibrant choice for students and call for major (radical?) changes to our curriculum to support this shift.

While there have been major efforts in recent years to adapt our curriculum to provide exposure to the excitement of statistics [see for example several of the rich datasets in Gould, (2010)], students need to be more directly engaged with a broad range of new data-related topics to be successful in our increasingly diverse discipline (Horton, 2016; Ridgway, 2015). The growth of data science poses many challenges and opportunities. As the authors describe, to be relevant in this world awash in data, statistics students need exposure to quantitative and qualitative approaches for the planning and design of studies, conduct and analysis, as well as interpretation and communication of results and implications.

I will briefly consider the implications of this paper as well as barriers for implementation of the approaches enunciated in this paper in two distinct areas: (1) our introductory courses as well as (2) our undergraduate programs in statistics.

1 Introductory Statistics

The introductory statistics class serves a key role in our curriculum-because this is often the only formal training in statistics for the majority of students. And there has been considerable ferment in recent years. Cobb concisely summarised these changes: 'for many decades now, our teaching of introductory statistics has been moving steadily away from mathematical treatment of abstract methods and models, in the direction of the practice of data analysis, and so in the direction of scientific inquiries in their applied contex' (Cobb, 2014). Qualitative methods help to provide grounding for students in the total picture of statistical analysis used to make decisions. Understanding the use of one-on-one interviews—as well as focus groups tools to develop research questions—should be incorporated as part of the design components of the course.

Clearly, there are barriers to include any new material in a course that is already overstuffed with topics and learning outcomes. The integration of qualitative elements will require creative approaches (along with the jettisoning of valuable material that is time-honored) but can help

ensure that students have the capacity to tackle more real-world problems. As a partial solution, some of these precursors need to be incorporated into K-12 education, particularly in secondary school, along with our introductory statistics and second courses at university (Horton, Baumer, and Wickham, 2015). Finzer (2013) suggests several such areas and opportunities at the secondary level. In addition, in the United States, the advent of the Common Core State Standards may prepare students to enter college with more understanding of statistical literacy and big-picture understanding. It is important for us to take a step back from our crowded syllabi to allow us to restructure the introductory statistics course to incorporate new ideas, including qualitative skills.

2 Statistics Curricula

There continues to be a dramatic growth in the number of students completing undergraduate degrees in statistics (Pierson, 2013). New guidelines from the American Statistical Association (ASA) call for such programs to equip students with quantitative skills that they can employ and build on in flexible ways (ASA, 2014; Horton and Hardin, 2015). They encourage statistics programs to emphasise concepts and tools for working with data—as well as provide experience in designing data collection and analyzing real data that go beyond the content of a first course in statistical methods.

These guidelines were updated to be more relevant in an era of increasingly large data, growth in the Advanced Placement Statistics program and the availability of increasingly sophisticated tools (and need for additional analysts to use them appropriately). At this juncture, the incorporation of qualitative topics to complement quantitative capacities is needed to ensure a workforce capable of integrating information and making decisions informed by data. The guidelines focus more attention on the ability to pose statistical problems, to 'wrangle data' that is considerably more complex than that presented in textbooks and to communicate these results in a correct and effective manner.

I will touch briefly on two particular areas of our curricula that call out for change. Firstly, aspects of the traditional probability/inference sequence, with its emphasis on large sample size approximations and lists of distributions, does not reflect current statistical practice. A modern statistical theory course might, for example, include more work on computer intensive methods and non-parametric modeling. The statistical theory course should provide students with an overview of statistics and statistical thinking that augments what is provided in their introductory statistics courses. It also needs to incorporate computing, data-related and communication components and some of the topics suggested by the authors. If included early on in a student's programs (as being implemented at a number of institutions), such a course provides a solid foundation for future courses and experiential opportunities.

Secondly, for most students, it is critical to further develop the ability to work with data, to understand the right questions to ask, to use a variety of computational approaches to manipulate data and find answers and to communicate results in a comprehensible and correct fashion. Working with data in this manner requires extensive computing skills far beyond what was needed in the past. In addition to facility with professional statistical analysis software, students require the ability to access and manipulate data in various ways, to program and to utilise algorithmic problem solving. While chairing the ASA undergraduate guidelines working group, I was struck by the potential for us to restructure our curriculum around the goal of developing skills and capacities for problem solving with data that includes important components of qualitative thinking.

In closing, I would like to congratulate Ograjenšek and Gal on a stimulating and important paper that lays out a number of challenges for the statistics education community.

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Discussion: The Q-q Dynamic for Deeper Learning and Research

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1 Quantify Qualification and Qualify Quantification

I surmise that most readers would agree that a dialogue about qualitative thinking versus quantitative thinking is unlikely to be fruitful, or even meaningful, without defining what these two thinking processes entail. However, the very desire for this definition highlights the difference between, and the need for, the two processes. For those who have strong training in quantitative thinking, the phrase 'defining' may induce a thought process to specify the boundary of each to the exclusion of the other, before attempting to argue their values in a contextualized framework. Those who feel more at home with qualitative thinking may rely on context to induce readers' own interpretations, or rather contextual associations, to discern between the two, as the dialogue unfolds.

Indeed, any reader who tries to locate the precise definitions of these two types of thinking in the article by Ograjenšek and Gal (2016) would be disappointed. A minor dose of qualitative