Who, What, When and How: Changing the Undergraduate Statistics Curriculum: A Discussion of "Mere Renovation is Too Little Too Late"

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First, and foremost, we largely agree with the underlying themes presented by Professor Cobb: the need for a curriculum that attracts, inspires and engages students preparing them for the data and analysis questions they will face in their future; that the curriculum of statistics needs to evolve to include more modern tools; our profession (and discipline) is in danger of being superseded by computer science, business analytics and bioinformatics; and the need for a curriculum that is dynamic in the face of the evolving role of data science, mathematics and computing.

The manuscript is a provocative and interesting piece that generated a good conversation between us and we expect that it will do the same for our colleagues. The four threads outlined are particularly noteworthy and the analogy to the fast food industry is chillingly accurate. With all that said, the manuscript raised several intertwined questions about the implications of such a dramatic shift to the curriculum. These can be summarized in three main discussion points. The first is on the role of curriculum, the second is a question of scale and the third is on the topic of competition and collaboration.

As described by Professor Cobb, historically intro courses were based on sampling distribution theory and required some mathematical chops to grasp the probabilistic and statistical rationale. Applications with real data were a secondary consideration and many statistical results were taught as a mathematical recipe for different types of theoretical data. Although the standard intro course has evolved to a more data driven approach and to include various computing techniques, the same build up from probability through inference is typically taught. Before we can completely abandon this approach, we need to address a fundamental question: What is the role of introductory statistics classes in the curriculum? From our perspective, our introductory courses serve three distinct clientele: all students (think the general public), statistical doers (majors requiring skills with data and analysis—the sciences) and proto-statisticians (those majoring in statistics, mathematics or computer science or who may get an advanced degree in the area). The teaching goals for each of these groups can be quite different and can be summarized as literacy, rationale and comprehension, respectively. The discussed revolution of the curriculum appears to largely concentrate on the rationale of statistics, moving to a more intuitive algorithmic approach, which in our mind largely serves the 'statistical doers.' How will this affect our other students? That is, what are the repercussions for the general public and the proto-statistician with such a dramatic change in teaching. Even with the 'statistical doers', the methods courses taught in their home departments often still expect a certain level of established tools (the two-sample t-test for instance). The issue is not merely in a change of *our* curriculum, but an entire shift in thinking with our client departments, the general public and our graduate programs as well.

Although the curriculum shift should benefit many aspects of statistical literacy (understanding the statistical comparison of groups using a randomization or a classification tree type approach, for instance), we potentially lose several important components in the traditional curriculum. The redesign efforts abandon much of formal probability for the sake of flattening the prerequisites. Even if this has an overall benefit and makes the subject matter more attainable, we must not lose sight of some of the key goals in statistical literacy such as a general understanding of uncertainty, randomness, chance and (shall we say) luck. For instance, in her 7 topics for the Educated Citizens, Jessica Utts highlights an understanding of natural variability (what is *normal* versus what is *the average*) as a fundamental element in statistical literacy (Utts 2003). Although we believe such topics can be discussed even with the flattening of prerequisites, the discipline needs to decide how to include such pertinent elements and how much time to dedicate to such topics.

Our second point is largely an issue with scale but does connect to the role of curriculum. We commend Professor Cobb and colleagues at the liberal arts colleges for providing numerous innovations in the statistics curriculum; but such changes create a set of challenges that need to be discussed. At many large research universities, more than 1000 students may take the intro stat course every semester, with many of these classes taught by adjunct faculty to large lecture sessions (∼100 students). There have been many calls for more active learning experiences in introductory classes in the recent past. Consider Project INGeInIOuS or the MAA/ASA/SIAM/AMS Common Vision Project, for instance. When faculty currently teaching intro stat are more comfortable with the traditional format, how do we convince them to use different pedagogical methods? How do we create space for faculty to innovate in a climate where we are already being asked to do more with fewer resources? At universities with undergraduate statistics programs, changes to the foundational courses will require major changes in upper level courses as well. Many of our students enter universities with AP credit; how do we incorporate those trained through a more traditional model at the high school level? Will a need for the traditional first course in statistics, as currently formulated, exist in the near

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future? How will the change in curriculum translate with other universities and graduate programs that build off the traditional model? And, although a good problem, are we ready for the additional demand a more attractive curriculum may create?

The last point we would like to make is our disagreement with the assertion regarding self-interest and the dangers to our field. Although we agree that other disciplines are infringing on traditional statistics material (the so-called *fast food*), where Professor Cobb appears to suggest the need to protect our field against external threats, we believe the current climate is one of opportunity rather than turmoil. At Miami University, the Department of Statistics partnered with the Farmer School of Business in developing a Co-Major in Analytics: students pick up data management proficiency, statistical methods for predictive modeling, data visualization, communication and teamwork skills, all with an eye towards application. This program has grown substantially since its creation in 2013 with roughly 70 current students. Recently, the Department partnered with the Department of Information Systems & Analytics, Computer Science and Marketing to form the Center for Analytics and Data Science as an interdisciplinary effort to address the analytics skills gap in the current workforce and foster collaborations in the areas of analytics and data science. Rather than going on the defensive, we encourage cooperation with other disciplines to build stronger programs. If implemented correctly, these associations can foster interdisciplinary research, strengthen the importance of computing, disseminate the skills our students need, and will secure and preserve statistics place as a major partner with other data-oriented disciplines.

References

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