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An Urgent Plea for More Graduate Programs in Statistics Education

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Synopsis

Lately, much has been written about the importance of amplifying statistics-related content in the K-12 curricula. This can be viewed in parallel or as an addendum to the existing mathematics curricula in the United States. Nevertheless, a key component of this debate is the lack of robust and cutting-edge academic programs in statistics education. In this piece, we emphasize the urgent need for investing in creating strong statistics education programs, which would significantly contribute to nurturing quantitative literacy as well as preparing a more informed citizenry in the 21st century.

Keywords: *statistics education, data science, statistical literacy*

As early as kindergarten, children are asked to make inferences with respect to data. This can show up formally when they are given a sequence of shapes: triangle, triangle, circle and asked to predict the next shape in the sequence or often informally in play. Making decisions based on data, in whatever form it takes, is not foreign for children. However not until Grade 6 do the Common Core State Standards for Mathematics introduce statistics [4].

Increasingly in the Information Age, citizens and knowledge workers need to understand statistics and data analytics. Yet high school and college mathematics have remained locked into a rigid industrial age sequence, which quite often looks something like this: introductory algebra, geometry, trigonometry, pre-calculus, calculus 1, etc. And some instructors and students still advocate the idea that students should not attempt to learn statistics until they have mastered calculus.

The Emerging Importance of Statistics Education

In a recent editorial [3], Jo Boaler and Steven Levitt note, "For the most part, students are no longer taught to write cursive, how to use a slide rule, or any number of things that were once useful in everyday life. Let's put working out polynomial division using pencil and paper on the same ash heap as sock darning and shorthand." Instead, they continue, "[e]very high school student should graduate with an understanding of data, spreadsheets, and the difference between correlation and causality."

In a widely viewed TED talk in 2009 [2], Arthur Benjamin, the Smallwood Family Professor of Mathematics at Harvey Mudd College, notes that, "[t]he mathematics curriculum that we have is based on a foundation of arithmetic and algebra. And everything we learn after that is building up towards one subject. And at the top of that pyramid, it's calculus. And I'm here to say that I think that that is the wrong summit of the pyramid ... that the correct summit — that all of our students, every high school graduate should know — should be statistics: probability and statistics." He adds, "Look, the world has changed from analog to digital, and it's time for our mathematics to change from analog to digital."

Learning statistics should be a priority for high school and college students. Implementing this priority will mean dramatically increasing the number of high school and college statistics courses. *This, in turn, will require increasing the number of teachers and professors who know statistics and who know how to teach it effectively.*

Call for Preparing Statistics Faculty

To prepare our future statisticians, a focus on preparing these instructors should be a national educational priority! And to prepare them we need

graduate programs in statistics education, akin to the growing number of graduate programs in mathematics education. As many nations transition from an industrial economy to an information economy, in a world of "Big Data" and data science, other countries have been moving statistics education to the fore. The Program for International Student Assessment (PISA) administers tests to secondary students from many countries. Their most recent guidelines identify six "key understandings which provide structure and support to mathematical reasoning, including understanding variation as the heart of statistics" [8].

We should not let this opportunity to move the United States to the statistical cutting edge of STEM education slip away. Thomas Jefferson believed that mathematics and science education were crucial to the development of a new nation. Jefferson invited the French minister of agriculture, DuPont de Nemeurs, to review education in the United States. Dr. de Nemeurs lamented that there were no textbooks on these subjects in the US at that time. Jefferson asked Congress for ten thousand dollars to write a textbook for each grade level relating science and mathematics to the welfare of the nation. Congress refused to allocate the funds. Paul DeHart Hurd has argued that this little-known decision was a critical turning point in the development, or lack of it, of American science literacy [5].

We call on the higher education community to respond to this need and create programs in statistical literacy. The American Statistical Association has developed and published guidelines for statistics education [1]. ASA's report comes with six recommendations for teaching statistics, including teaching statistical thinking, focusing on conceptual understanding, integrating real data with a context and a purpose, and using technology to explore concepts and analyze data.

We have been focusing on statistics education for single-subject teachers in middle and high school, as well as for university professors. There also is a need for elementary teachers to have some instruction about statistics and how to teach it. Studies repeatedly reveal that children enter kindergarten alive with curiosity about the natural world, but by the end of elementary school they are much less interested in math and science concepts [11, 9]. Often this is because their teachers are uncertain and hesitant about these subjects, if not fearful. Some college students choose to major in elementary education so that they can avoid math courses.

Statistical reasoning has been an important component of the intellectual development of mankind. Graduate students studying evaluation learn to guard against "selection effects" (i.e., Is the difference in outcomes between the treatment and control group actually because the two groups differed prior to the experiment — not because of the treatment or intervention?). But the ancients had recognized the same dilemma, with the phrase "*post hoc, ergo propter hoc*". According to the Merriam Webster dictionary, the translation and meaning of this phrase is, "after this, therefore because of this: because an event occurred first, it must have caused this later event — used to describe a fallacious argument" [7]. Over millennia, many nations and cultures have contributed to statistical thought, e.g., the Islamic world and India.

We believe the exposition of the concepts of variation, estimation, statistical modeling, and statistical prediction in the K-12 curriculum is elemental in achieving quantitative literacy in our nation's school systems. Such a reformed curriculum would hopefully close the gap in our students' appreciation of the underlying theme in the statistical thought process, namely improving "decision making under uncertainty".

Statistical Analysis and COVID-19

One can argue that at no point in the past century has the understanding of the fundamentals of the statistical approach been so crucial as in the emergence of the recent global COVID-19 pandemic, resulting from the spread of the novel coronavirus, SARS-CoV-2.

There are more than a handful of fairly sophisticated modeling engines, developed by the leading researchers in the areas of epidemiology, statistics, and mathematical biology. Some of these models are used by the Centers for Disease Control and Prevention (CDC). Many news organizations and platforms publish the output of those models on a daily basis. Despite the role they can or do play in macro-level or individual-based decision-making, they predominantly remain pointwise in nature, lacking the critical notion of including uncertainty levels associated with them. This, we think, affects the public's awareness, mobility and behavioral patterns, and is at least partially related to the deficiency of statistical education and statistical literacy. More importantly, understanding uncertainty clarifies the role that random fluctuations, resulting from political nuances and global events, can play when utilizing such statistical models for decision making.

Christine Franklin has noted, "The international community is being called upon to process and make sense of data — from screening test results and risk analysis regarding vaccines, to statistical models predicting numbers of cases, deaths, hospitalizations, and time to herd immunity. Data is also being used to recommend best practices to combat the spread of the virus. Meanwhile, data is called on to address other global issues such as climate change, the economy, elections, and social justice. Surely, it should no longer be optional for our school-age students to develop statistical reasoning skills. It should be mandatory that all students leave secondary school prepared to live and work in a data-driven society." [6]

Preparing Future Statisticians for 21st Century Jobs

Moreover, there is a practical side to teaching and learning statistics: students who earn degrees in statistics can get jobs, as evidenced year after year through various national surveys, demonstrating "statistician" topping the rankings among the best jobs in industry [10].

We have entered an age of information, Big Data, and analytics. We need to equip students with the knowledge to understand the multi-faceted nature of modern data, as it grows exponentially, and to know how to use data to make informed decisions. We need a national movement to prepare teachers at the K-12, college and university levels through innovative teaching–credential, masters, and Ph.D. programs in Statistics Education.

References

[1] Anna Bargagliotti, Christine Franklin, Pip Arnold, Rob Gould, Sheri Johnson, Leticia Perez, and Denise A. Spangler, "The Pre-K–12 Guidelines for Assessment and Instruction in Statistics Education II (GAISE II): A Framework for Statistics and Data Science Education", American Statistics Association, 2020; available at https://www.amstat.org/asa/files/pdfs/GAISE/GAISEIIPreK-12_Full.pdf, last accessed on January 10, 2022.

[2] Arthur Benjamin, "Teach statistics before calculus!" TED talk, 2009; available at http://www.ted.com/talks/arthur_benjamin_teach_statistics_before_calculus?language=en#t-22185, last accessed on January 10, 2022.

[3] Jo Boaler, and Steven D. Levitt, "Opinion: Modern high school math should be about data science not Algebra 2", *Los Angeles Times*, October 23, 2019; available online at https://www.latimes.com/opinion/story/2019-10-23/math-high-school-algebra-data-statistics, last accessed on January 10, 2022.

[4] Common Core State Standards Initiative (CCSSI), *Common Core State Standards for Mathematics* (CCSSM), National Governors Association Center for Best Practices and the Council of Chief State School Officers, Washington, DC, 2011; available at http://www.corestandards.org/wp-content/uploads/Math_Standards1.pdf, last accessed on January 10, 2022.

[5] David E. Drew, *Aptitude Revisited: Rethinking Math and Science Education for America's Next Century*, The Johns Hopkins University Press, Baltimore, 1996.

[6] Christine Franklin, "As Covid Makes Clear, Statistics Education is a Must", *Significance*, Volume **18** Issue 2 (2021), page 35. doi:10.1111/1740-9713.01509

[7] Merriam-Webster, "post hoc, ergo propter hoc", Merriam-Webster.com online dictionary, Merriam-Webster, Incorporated, 2021; available at https://www.merriam-webster.com/dictionary/post%20hoc%2C%20ergo%20propter%20hoc, last accessed on January 10, 2022.

[8] OECD, *PISA 2021 Mathematics Framework*, OECD Publishing, 2018; available at https://pisa2021-maths.oecd.org/#Overview, last accessed on January 10, 2022.

[9] Carl Sagan, "Why we need to understand science", *Parade Magazine*, September 10, 1989.

[10] U.S. News & World Report, "Statistician Ranks Among Best Jobs of 2020.", *U.S. News & World Report*, 2020; available at https://money.usnews.com/careers/best-jobs/statistician, last accessed on January 10, 2022.

[11] Robert E Yager and John E Penick, "Perceptions of Four Age Groups Toward Science Classes, Teachers, and the Value of Science", *Science Education*, Volume **70** Number 4 (1986), pages 355–363.