STATISTICS FOR ALL STUDENTS

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How can statistics instructors - at the high school and college level - make the development of statistical thinking and 21st century skills accessible to all students? Alongside the rise of Big Data, the ability to reason statistically will appreciate; all students need a strong introductory statistics course to prepare them for the statistical demands they will encounter in higher education, work, and engaged citizenship. The traditional high school coursework neglects statistics for all but advanced students. With the Common Core State Standards for Mathematics, there is an opportunity to infuse statistical thinking into each grade level for all K-8 students, followed by a choice of statistics courses (Advanced Placement or non-AP) in high school. To take advantage of this opportunity, all math teachers must be adequately trained in statistics. Furthermore, secondary and post-secondary educators must work together meet the demands that will be placed on all of our students.

INTRODUCTION

One of the ways that we measure the quality of life and equity in a country is access to education. How many people in country X can read? How many can write? How do the citizens score on math tests? What percentage of the population has access to a computer? The Internet? Let me propose an addition: how many the people have the knowledge needed to understand and employ statistical thinking? Is this knowledge concentrated among a few, or distributed among the general populace?

Perhaps as statistics teachers we can agree that, "everyone should take a statistics class." I propose that the rise of Big Data - increased data collection and prevalence of data analysis in work and community life - makes this recommendation an issue of access/equity. It is commonly understood that literacy is a necessary part of every child's education. I pose that a basic level of statistical literacy/fluency merits a similar position in our conception of an educated person, and that it is our responsibility as teachers to push for changes that make statistical literacy available to all students. A statement that takes some responsibility for this recommendation is that "everyone should have *access* to a statistics class." The proposition that all students have access to basic statistics knowledge requires several changes in the high school and college environments.

What follows are four recommendations for structural and pedagogical changes in statistics education that derive from my five years' experience teaching statistics in an urban high school in California, United States. In the beginning, I taught my class by learning the material from the textbook just ahead of the students. I was willing but unable to support students in developing their statistical thinking and I realized that I was unprepared. I sought support from colleagues, but statistics teachers were scarce and support structures were nonexistent. In the meantime, Big Data became increasingly ubiquitous; the "New Natural Resource" for the society of the future.

In brief, the recommendations to be discussed are:

1. Teachers should change how we teach statistics to offer students experience *doing* statistics at secondary and post-secondary levels.
2. Secondary schools must offer an introductory course in statistics (other than Advanced Placement Statistics).
3. Teacher certification agencies must create formal structures for teaching statistics in secondary schools.
4. Universities must expand teacher preparation programs to include statistics specializations

RECOMMENDATIONS

First, I propose a shift in how we teach statistics at the secondary and university levels. To have "stats for all" be our goal implies an additional onus on teachers and professors: we must

teach in ways that reach more students. Educator and constructivist Maria Montessori wrote, "education is not what the teacher gives; education is a natural process spontaneously carried out by the human individual, and is acquired not by listening to words but by experiences upon the environment" (Montessori). If we want to offer statistics education for all students, then we must teach it in a ways that allows students to do statistical thinking for themselves.

- *Number one*: use demonstrations, simulation, true stories, and other realia wherever possible. True stories and real-life physical experience provide more salient experiences for all students, and an entry point for students who struggle with traditional lecture format instruction.
- *Number two*: encourage group work. Social constructivist learning theory says that people learn by negotiating meaning with other people within their shared environment. In order for students themselves to think statistically (rather than follow someone else's statistical thinking), they must have opportunities to work together on challenging problems, compare their reasoning, and consult with each other.
- *Number three*: consider offering basic statistics as a lab-enhanced course akin to introductory biology or chemistry. Students need the opportunity to use the techniques and technologies employed in the practice of statistics; it is not enough to learn *about* these tools. In a lab section, students could work on statistical problems receive guidance about their thinking.

Second, in the United States, secondary schools must develop an introductory statistics course to offer alongside Advanced Placement Statistics[1]. Such a course would provide a background in fundamental statistical topics: randomness, experimentation, sampling, descriptive statistics, regression, and probability. Students are progressively more surrounded with statistical information in the news and media. Decisions ranging in importance from the pivotal - whether or not to vaccinate a child, or how governments allocate tax revenue - to the trivial - which restaurant to try or cell phone to buy - are informed by statistical thinking. A rigorous introductory study of essential statistics topics would facilitate students becoming adept users of the statistics and data all around them. In turn, statistics can help students become critical, independent thinkers.

Third, if we are to offer statistics courses to more students, we will need an army of teachers well-trained to teach statistics well. At present, the only way to become a statistics teacher is to teach statistics. Where I teach - California - there is no teaching credential, license endorsement, or qualification assessment statistics teachers. In California, there are 39 subject examinations for high school teachers but no statistics exam (Tests). The same is true in most other states. The Praxis II series, a nationally recognized competency test for secondary teachers, offers three different tests for math teachers (content knowledge, proofs/models/problems, and middle school math) but no option for statistics. Despite the clear importance of data and statistical thinking for our students' futures, at present the United States does not prepare teachers to become knowledgeable practitioners in the field. With the recent shift toward the Common Core State Standards, which infuse statistics concepts throughout the newest K-12 standards, such preparation is critical.

Fourth, to generate knowledgeable, effective statistics teachers, universities must expand teacher preparation programs to include statistics specialization. In their 1998 paper, Chris Wild and Maxine Pfannkuch stated that, "the cornerstone of teaching in any area is the development of a theoretical structure with which to make sense of [our] experience, to learn from it and transfer [our] insights to others." (Wild, 335) It may sound obvious, but teachers must know statistics in order to teach statistics. The current teacher preparation program ignores teachers' need for explicit training to be successful in statistics classrooms, perhaps on the assumption that a strong math background is sufficient. Statistics educators in the university context are well-positioned to work with education departments to push for stronger teacher preparation in statistics through creation/development of statistics course offerings for educators.

Finally, statistics educators need to champion the value of statistics education for all students. This could take many forms, such as offering to develop/teach a statistics course for educators, trying new teaching techniques to reach more of your students, or increased engagement between secondary and university statistics educators in your area. Who but statistics teachers is better positioned to press for these changes? People in other professions - policy makers, education

researchers, nonprofit organizations - can observe the rise of Big Data and the gap between the skills students have and those they need; statistics teachers alone have the responsibility to meet the rise of Big Data with a rise in the everyday statistician, by which I mean that a greater swath of students must be prepared to harness data to make the world more just, secure, and sustainable. If we continue to train relatively few students in statistics, then statistical thinking and understanding will be confined to relatively few uses. However, if statistics teachers work to reframe to whom statistics belongs, then we could unleash previously untapped potential of non-statisticians to creatively address problems using the growing hoard of available data. Thusly, the lack of statistical skills can be argued to inhibit social progress, so statistics education cannot remain a luxury for the few; it must be seen as a necessity for all.

CONCLUSION
        The value of statistics education has increased with the collection and availability of data, placing both an opportunity before and a responsibility upon teachers of statistics. We must lead our secondary schools and universities and teacher preparation programs toward the capacity to offer rigorous statistics education to all students in all schools.

ENDNOTE
[1] Advanced Placement Statistics is a high school course offered across the United States. It was created and is closely regulated by the College Board, an American nonprofit organization. The College Board also administers college-entrance exams in the United States.

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