Interview with Josh Tabor

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Josh Tabor teaches at Canyon del Oro High School in Oro Valley, Arizona. He has served on the Test Development Committee for the Advanced Placement program in Statistics and was one of five finalists for Arizona Teacher of the Year in 2011. This interview took place via email on October 5 – November 8, 2014.

Beginnings

AR: Thanks very much, Josh, for agreeing to be interviewed for the Journal of Statistics Education. *Let's start with those two words – statistics and education. Which were you interested in first?*

JT: Hi Allan! First, let me thank you for this opportunity. It is quite an honor to be among the group of great statistics educators that you have interviewed so far. I hope I can contribute something useful.

Now, to your question: I was interested in education before I was interested in statistics. In fact, I didn't even know that I loved statistics until I started teaching it. And I wasn't even sure about education until I was a sophomore in college. At Biola University I started as a business major, hoping to be a financial planner of some kind. I was also minoring in math as a way of distinguishing myself and because I enjoyed the subject. Many of the students in my math classes were planning to be teachers, so the thought of becoming a teacher started to bounce around in my head during my freshman year. In the fall of my sophomore year, I was inspired

by a chapel speaker to consider how I could best make an impact on other people. I know "making an impact" sounds cliché, but it was shortly after this chapel service that I decided to major in mathematics and become a teacher. My experience as a math major at Biola was great, and I have never regretted the decision to become a teacher. I am very thankful that I figured out my calling early in life.

AR: That leads to an obvious next question: How did you come to be a statistics teacher? Were you assigned to teach statistics early in your teaching career? Did you volunteer, or have your arm twisted? Did you approach the task with trepidation, or with enthusiasm, or with some of both?

JT: Right after college I got a job teaching at Wilson High School in Hacienda Heights, CA. During my first year (1995), my department chair encouraged us to attend the California Mathematics Council Annual Conference in Palm Springs.* While at the conference, I attended a session called something like "AP Statistics is coming—come find out more about it." This was the year before AP Statistics was offered anywhere in the country. I went, thinking that this might be a good opportunity to teach upper-level students. Plus, I had been using some statistics to help me with my fantasy baseball team, so I had a growing interest in the subject. I proposed the new course to my department chair and principal and they loved the idea. I spent the rest of the year recruiting students and started the 1996-1997 school year with two sections of AP Statistics. I was excited going in, but had no idea how much I was going to learn in the coming months and years.

> * This is an excellent conference for K–12 math teachers. I have been back as a participant and speaker on many occasions. There is usually a nice track of statistics sessions and a great exhibit hall.

Teaching AP Statistics

AR: That's great that you went in with enthusiasm rather than trepidation, and that you even initiated the course development yourself. How did you teach yourself some statistics and prepare to teach the course for the first time?

JT: The first thing I did was sign up for a 1-week summer institute for AP Statistics. The instructor, Gretchen Davis, was great. She had a passion for teaching statistics and shared everything she could with us. After the workshop, she continued to mentor me and several other teachers who lived in the Los Angeles area for the next several years. We would meet monthly to share resources and encourage each other. In that first summer I also read our textbook (*Introduction to the Practice of Statistics* 2e, by Moore and McCabe) from cover to cover, trying to learn as much as I could. The final step in the process was joining the AP Statistics listserv, now known as the AP Statistics Teacher's Community. On the list I found many other teachers just like myself—new to statistics and trying to figure out what might be on the first AP Statistics exam. Fortunately, the list also included some experienced high school teachers (hi Chris Olsen!) and generous college professors (hi Bob Hayden!) who would patiently answer our questions, no matter how easy or off-target they were.

Nowadays, it is easier (but not easy) to begin teaching AP Statistics. There are many more resources available, including actual AP Statistics released exams. But my advice to new teachers would be similar to what I described above: (1) Attend an AP summer institute. (2) Find a local support group. (3) Get very familiar with your textbook. (4) Join the AP Teacher's Community. You might consider doing #4 first, as it will make it easier to find information on the other 3.

AR: As you say, that was the very first year that the AP Statistics exam was given, so you and all other teachers must have been a bit anxious about what the exam would be like. May I ask how your students did on that first exam? And what changes, if any, did you make in your teaching based on that first exam?

JT: My students were quite nervous about taking the very first AP Statistics exam. Unlike my current students, they had no previous exams to practice with and the book we were using was written for a college class, not specifically for AP Statistics. To encourage them to take the exam, I made them a deal. Before I explain the deal, I need to fill in a few little-known details about my life. When I was a student teacher two years earlier, I was very short on cash. To save money, I stopped getting haircuts. Once I became a teacher, I started getting paid, but still didn't get a haircut. By the time of the first AP exam, my hair went several inches below my shoulders. Of course, my students thought my hair looked awful and were constantly begging me to cut it. So that brings me to the deal: I had 52 students, so I said if 26 passed the AP exam, I would host a pizza party in the summer and let each of them cut off part of my hair. Even with that motivation, only 32 signed up for the exam. But 30/32 ended up passing! So, in August 1997, I said congrats to my students and goodbye to my hair.

I made plenty of changes based on my experiences the first year and what I learned about the grading of the exam. The most notable change was an emphasis on checking the conditions for inference, something I paid little attention to the first time through the course. There were plenty of other insights that I gained, but I don't think I had a good sense of the bigger picture until I became an AP Reader in 1999 and attended the Statistics Leadership Institute at the North Carolina School of Science and Mathematics that same summer.

AR: Great story! I wonder how you motivate your students now that you can afford to have better personal grooming habits. But that's not really my next question. Please tell us about that Statistics Leadership Institute and some of the insights you gained there.

JT: In the summer of 1999, after my third year of teaching AP Statistics, I was selected to attend the NCSSM Statistics Leadership Institute. The institute was a three-week crash course in post-AP content, organized by Dan Teague and taught by many prominent college faculty including Dick Sheaffer, Jeff Witmer, Linda Young, Bob Stephenson, Jon Cryer, and several others. Fifty secondary teachers attended the institute at the North Carolina School of Science and Mathematics, staying in the dorms, and immersing ourselves in statistics day and night. During the three weeks, we learned about topics ranging from mathematical statistics to multiple regression and advanced experimental design. Although these topics aren't part of the AP curriculum, understanding what comes next made me a better teacher, just like an Algebra 1 teacher can benefit by understanding what happens in an Algebra 2 course.

AR: The AP Statistics course is designed to be comparable to an introductory university course in statistics. Let me ask a question that I often ask of candidates of faculty teaching positions: What topic in the course do you find most challenging for students to understand, what do you think makes the topic so difficult, and how do you help students to understand the topic? (I realize that's three questions disguised as one!)

JT: Probably probability. Actually, it is definitely probability—I just couldn't resist the play on words. I think this topic is difficult for students for many reasons, but the diversity of probability questions is probably (there I go again) the top reason. When we study each individual topic, such as binomial distributions, students are able to manage. But when all of the topics are mixed together on a cumulative exam, their heads start to spin. The homework question that was easy in Section 6.2 is a challenge on the Chapter 6 exam and nearly impossible on the final exam. Over the years, my approach to teaching probability has evolved (and continues to evolve). Whenever possible, I avoid formulas completely or put them off until the end of the lesson. Students find that conditional probability is fairly intuitive when using a two-way table. Using the conditional probability formula makes it more complicated. I also use simulation much more to develop the idea of probability and to introduce topics such as combinations of random variables.

AR: You mentioned earlier that your participation in the AP Reading, beginning in 1999, provided you with valuable insights about teaching the "big picture" of statistics. Would you elaborate on some of those insights?

JT: Two things come to mind. When I was a new statistics teacher, each section and each chapter seemed like a distinct set of topics, unrelated to the surrounding sections and chapters. For example, I didn't clearly see the connection between sampling distributions and inference, even though this connection seems obvious to me now. AP exam questions have a nice tendency to focus on these connections by integrating topics from throughout the curriculum. As an AP reader, I became intimately familiar with these types of questions and how to answer them.

Second, the following pattern kept repeating itself:

- Me before the reading: "I finally know how to teach topic X."
- Me at the reading: "I guess I didn't know how to teach topic X."
- Me after discussions with fellow readers: "Now I actually know how to teach topic X."

Topic X in 1999 was confounding, as illustrated by the dentist and apple question. Later topics included random assignment, standard error, blocking, and so on. I don't think my experience is that unusual for high school statistics teachers. Most of us come to the course with very little background and very little local support. Having the opportunity to attend the AP reading has been a wonderful professional development experience.

Outside of the AP reading, I continued to read the AP Statistics listserv religiously and attend as many workshops as I could afford. Whenever I would attend a math conference, I would immediately search for all of the stats sessions and go to as many as possible. In short, I was a statistics sponge, soaking up everything I could.

AR: What kinds of students have taken your AP Statistics courses over the years? For example, are they generally good at math, afraid of math, somewhere in between, or is there lots of variability? And what are their primary motivations for taking the course – desire to test out of a college course, or interest in the subject matter, or something else?

JT: There is lots of variability in my students, which is very appropriate for a course that some define as the study of variability! Some of my students are co-enrolled in AP Calculus BC and others come directly from Algebra 2. Some of the students are quite happy with the emphasis on reading and writing in the AP course, and others are dismayed that the only number on some pages comes in the upper-right corner. When we get to probability and random variables, the roles reverse and my mathy types are much happier.

As for their motivation, I think most of them are hoping to better prepare themselves for college. I actively recruit students each spring by visiting other math classes and letting them know about the course. My "pitch" usually includes discussing a recent example of statistics in the news* and a discussion of how statistics will prepare them for college. This includes a discussion of earning college credit but also focuses on the wide range of majors that require a statistics course. I also share an email or two from former students who are thankful that they know more than their peers in psychology, sociology, chemistry, and biology classes.

> * Two years ago I got a lot of interest with the story of how Target found out a teen was pregnant before her father did. Check out http://www.forbes.com/sites/kashmirhill/2012/02/16/how-target-figured-out-a-teen-girl-was-pregnant-before-her-father-did/.

You also mentioned "interest in the subject matter" as a possible motivation. Other than what they hear in my pitch, this is generally not a motivating factor. In fact, I typically have to fight against the perception that statistics is just a bunch of tedious calculations and graphs. I am hoping that the new statistics standards in the Common Core will help with this perception in the coming years.

Common Core State Standards

AR: You keep providing me with perfect segues to a new question. Let's talk about the Common Core State Standards. I've talked about the CCSS with previous interviewees such as Mike Shaugnessy and Chris Franklin, but you're the first high school teacher that I can interview about this. First, please summarize the CCSS standards for statistics.

JT: That's not an easy question! I've taught day-long workshops and wasn't nearly able to address each of the Common Core Standards. Some of the standards will be familiar to many teachers—making and describing univariate displays, scatterplots with lines of best fit, and so on. It is the "new" standards that I get most excited about. Students are expected to understand how study design affects the types of conclusions that can be drawn from a study. Students are also expected to use simulation to do informal inference—estimating a margin of error and testing whether the difference between two statistics is significant. This means that all students will experience the entire statistical process, from designing a study to making a conclusion.

Now those "tedious calculations and graphs" I referred to earlier have a purpose as the bridge between study design and inference.

There are a number of new probability standards, including ones about normal distributions, conditional probability, and independence. I am hoping that exposure to these standards might eventually change my answer to your previous question about what topic is hardest for my students. There are also some "optional" standards that focus on using probability to make decisions, such as when a football team should "go for it" on 4th down. These optional standards are typically saved for a 4th year course and not included in grades 9–11.

AR: Your earlier comment gave the impression that your overall attitude toward CCSS is an optimistic, hopeful one. Is my impression right? If so, what's the basis for your hopefulness?

JT: I am optimistic and excited about the CCSS. I think the statistics standards are a major step forward for statistics education in K–12. To be honest, I haven't spent a lot of time studying the non-statistics standards, so I don't have much to say about them.* My greatest hope is that the political controversies surrounding the standards don't derail the progress we are making in statistics education. Unfortunately, I don't really have a basis for this hopefulness.

> * Actually, my daughter was homeschooled last year and I was her 2nd grade math teacher. I was generally happy with the standards for her grade, including the focus on place value and different ways to model addition and subtraction.

AR: At first I misread "place value" as "p-value" and couldn't decide whether to be amazed or appalled that you were trying to teach p-values to your second grader! I think it's fair to say that two of the substantial challenges to a successful implementation of the CCSS, with regard to statistics, are faculty development and assessment. Let's take those one at a time, starting with faculty development. You mentioned that all high school students will be expected to study and learn the overall statistical process from data collection to statistical inference. Most high school math teachers majored in mathematics rather than statistics. Do you think teachers are well-prepared to help students to learn and understand the process of conducting statistical studies? What can be done, and what is being done, to help teachers who have never studied statistics or who only studied mathematical aspects of the field?

JT: This is an easy question! Teachers are very poorly prepared to teach the majority of statistics and probability standards in the Common Core. I know better to generalize from a non-random sample, but I am going to do that anyway. As I talk with teachers at workshops for AP Statistics, the majority have taken at most one statistics course. And that course was most likely formula-driven or at a much higher level that is helpful for teaching the CCSS (e.g., mathematical statistics). For the most part, teachers are starting from scratch, which makes them very uncomfortable. And these are the teachers who volunteered to teach AP Statistics. I can only imagine how uncomfortable the other teachers are!

There are at least two ways to address this problem: better curriculum and professional development. Unfortunately, there is room for improvement in both areas. Textbooks aimed at grades 9–11 have added content to address the statistics and probability standards, but in some

cases the material is not in the spirit of the CCSS. For example, a few of the books I reviewed last year address the inference concepts with traditional formulas, not simulation. This makes it much harder for students to understand the logic of inference and the connection to study design. Professional development for the CCSS is increasingly common, but I don't see many workshops that focus on the statistics and probability standards. There are some groups working on addressing this shortcoming, but I would like to make a plea to those who are still reading: Please become familiar with the statistics and probability standards for the CCSS (see www.corestandards.org/Math/) and reach out to schools in your area. Teachers need all the help we can get.

AR: Let's turn to the assessment component of CCSS, where I have several questions about the statistics standards. First, do you agree that effective assessment will be crucial to the success of CCSS? Second, can you summarize what the planned assessments will be like? Third, have you been impressed with the quality of the assessment questions that have been released thus far?

JT: Hey—you snuck three questions in there! Let me answer them in order:

(1) Effective assessment will be crucial to the success of the CCSS, along with effective curriculum. Unfortunately, many of the criticisms I hear are not actually about the standards themselves, but about the way they have been implemented or the way they will be assessed. When talking with people I always try to make this distinction to help frame the conversation. The reality of teaching K–12 is that the assessments drive what happens in the classroom. If the statistics items are marginalized on the assessments or the items are trivial (e.g., find the mean of 7 numbers), statistics will continue to be pushed out of classroom instruction. But if quality statistics items are included on the assessments, we should see a meaningful improvement in statistical literacy for all students. Overall, if the assessments aren't well-done, there will be an even bigger push away from the CCSS.

(2) Originally, nearly all states agreed to be part of one of two assessment consortia: PARCC or Smarter Balanced. The task of these consortia is to develop high quality assessments that go beyond the typical multiple-choice style standardized exams. Ideally, these exams would be administered on computers, so that there would be more flexibility in the type of questions that could be asked. However, because of funding concerns, paper-and-pencil forms have been developed as well. Since the original agreement, many states have withdrawn from these consortia and are making other plans, including my state Arizona. In fact, at this moment (October 2014) we don't know what assessment we will be giving later this year!*

> * On November 3, 2014, Arizona announced that it would be using assessments developed by the American Institutes for Research (AIR).

(3) There haven't been very many statistics items released to this point, unfortunately. This makes things even more difficult for teachers, as they have very little idea what will be emphasized or what types of questions might be asked. But I would like to point out an example from PARCC, which nicely addressed the differences between observational studies and experiments. See the Green Tea Observational Study task at

www.parcconline.org/samples/mathematics/high-school-mathematics. My hope is that this item isn't an outlier, as it gets at some very important concepts.

Writing Assessment Items

AR: I know that you've been involved with helping to write large-scale assessment items for the AP Statistics program. Have you had any direct experience with writing items for the CCSS standards?

JT: I haven't been involved with either PARCC or Smarter Balanced, but I have recently been working with two other groups that are developing new assessments that include some of the statistics and probability standards from the CCSS.

For the past 3 years, I have helped to write items and develop the LOCUS (Levels of Conceptual Understanding in Statistics) assessments. LOCUS is an NSF-funded project to develop assessments that roughly correspond to the three-levels in the GAISE framework (see www.amstat.org/education/gaise/). The content of the exams overlaps quite a bit with the statistics and probability standards in the CCSS, although LOCUS goes a little farther. Even so, the LOCUS items are written in the same spirit and can be useful for illustrating the types of questions that might be asked on CCSS assessments. They can also be used to measure growth for students in a high school or college statistics course, which is how I am using them this year. See locus.statisticseducation.org/ for more information about the items and how you might use them.

For the last year, I have been a member of the Mathematics Development Committee for the SAT. The SAT is undergoing a major redesign, both in content and in format (e.g., 4 options instead of 5, no penalty for guessing). The redesign will become operational with the PSAT in Fall 2015 followed by the SAT in Spring 2016. Fortunately for us, there is a much greater emphasis on meaningful statistics and probability than in the current version of the SAT. Roughly 29% of the items will come from the Problem Solving and Data Analysis domain, which include items about statistics and probability, in addition to problems about ratios, percents, and unit conversions. There will still be items that ask about basic univariate data analysis (e.g., means and medians), but there is also a big emphasis on bivariate data analysis for both quantitative and categorical data. Even more importantly, there will be items that ask students to determine when it is appropriate to make cause-and-effect conclusions and when it is appropriate to generalize results to a larger population. There will even be items about margin of error! See www.collegeboard.org/delivering-opportunity/sat/redesign for much more information about the revised SAT.

AR: When you served on the AP Statistics Test Development Committee, you helped to write a question that I have described as my all-time favorite assessment question (See item #6 at: http://apcentral.collegeboard.com/apc/public/repository/ap09_frq_statistics.pdf). You then co-authored a JSE *article that conducted an investigation of some of the statistics that were proposed in student responses (Tabor 2010). Can you discuss how difficult it is to write effective large-scale assessment items by committee, how you think that process can be most effective, and*

what you see as some key characteristics of good assessment questions? (Sorry, there I go asking three questions at once again!)

JT: Writing assessment items for large-scale assessments such as the SAT or AP Statistics exam is very challenging. Every word needs to be carefully considered, as students aren't able to ask clarifying questions like they could in my own class. We carefully consider the appropriateness of the content and avoid situations where specific knowledge of the context might provide an advantage. It is not uncommon to spend an hour or more on a single multiple-choice item. And some free-response items take a year or longer to develop completely.

To make sure the assessments are fair for all students, each of the committees I have worked with has been carefully constructed to include members with different backgrounds and expertise. There is typically a good balance of college and high school faculty, along with professionals from ETS and/or the College Board. Teachers come from both public and private schools, urban and suburban. On the SAT committee, some members have expertise in algebra, others in geometry or statistics. Likewise, some are experts in graphing calculator use and others take a more traditional approach. Fortunately, every member shares one common trait—the desire to create assessments that reliably measure student understanding.

Here are a couple quick thoughts about how to write good assessment questions, although I am definitely not an expert: When I write a multi-part item I try to make part (a) very similar to an easy homework question, part (b) similar to a harder homework question, and part (c) something slightly different than they have seen before. This way, all students can access at least one of the parts and even the best students are challenged to think on their feet by the end of the item.* Some examples of this structure can be found on the 2011 AP Exam (see items #1 and #2 at apcentral.collegeboard.com/apc/public/repository/ap11_frq_statistics.pdf). For multiple-choice items, I try to avoid mixing too many concepts together in one item. If there are too many concepts in an item, it is difficult to learn where students are having trouble. Finally, I have tried to move away from questions about topics on the periphery and focus on the core concepts. When studying for the final exam (or AP exam), I want students to use each chapter test as a summary of the most important ideas that we covered.

> * Asking challenging questions means that I need to scale the scores on my exams, much like they do on the AP exam. Although it varies by chapter, students who get raw scores above 80% almost always earn and "A" and students with raw scores above 50% typically earn at least a "C."

AR: Sticking with the assessment theme, one of the criticisms that has been directed at the American educational system, particularly with initiatives such as No Child Left Behind, Race to the Top, and now the Common Core, is that students are over-burdened with taking large-scale assessments and that teachers concentrate on "teaching to the test" rather than instilling a love for learning and the ability to learn how to learn. What's your take on this concern?

JT: As a person who has been involved in writing some of these large-scale assessments, you won't be surprised that I think they play a valuable role in the world of education. They are useful not only for accountability and college admissions, but as a way to encourage learning.

And I certainly don't believe that preparing students for a test and instilling a love for learning have to be mutually exclusive.

Your question also asked about helping students learn how to learn. I think this is an incredibly important goal—and one that can be facilitated by good assessments. After all, much of what we are teaching students in school today may be obsolete in a decade. No longer can students expect to take the skills they learn in school and use them in the same job for 40 years. At a rate never before seen, jobs are changing, moving, or being eliminated and workers need to keep themselves employable. Employability means adaptability and the ability for an individual to apply his or her knowledge in new or unexpected ways. The Investigative Task on each AP Statistics exam is a great example of how an assessment can encourage this ability. This task, worth 1/8 of the entire exam score, is specifically designed to take students out of their comfort zone by asking them to make new connections and apply their knowledge in a different way. The item you mentioned in the previous question is one of these investigative tasks. For more examples, see question #6 on any free-response section of the exam (apcentral.collegeboard.com/apc/members/exam/exam_information/8357.html).

Your question also included a phrase that always gets my attention: "teaching to the test." Many people use this phrase with the expectation that listeners will automatically translate it as "bad teaching." In many cases, however, I think "teaching to the test" is exactly what we should be doing. Like I described above, well-designed assessments focus on the most important content, so teaching to the test should mean teaching the most important material. I have absolutely no problem telling people that I "teach to the AP exam" in my AP Statistics class. This means I make sure to cover the prescribed topics, give students practice with items like the investigative tasks mentioned in the previous paragraph, and share insights about common student errors that I have learned from the scoring rubrics. At the end of the year, I am confident that my students are not only prepared for the AP Statistics exam, but that they have developed an appreciation for statistics and will be able to apply what they have learned in whatever discipline they study in college.

Regarding the SAT, I think the redesign has successfully addressed many of the traditional criticisms. There is no longer a penalty for guessing, so some of test taking strategies that people equate with "teaching to the test" are no longer in play. There is also more transparency with regard to the content that will be assessed on the exam—and this content is much better aligned with what is taught in the classroom. The material students are learning in school will help them do better on the SAT, and preparing for the SAT will help students do better in school. As a classroom teacher, if my students were going to an SAT prep school on the weekends, I would be quite happy!

Teaching Statistics Through Sports

AR: I appreciate your optimism and your reminder that "teaching to the test" is not a bad thing if the test does a good job of assessing valuable learning objectives. Let me shift our conversation to less controversial issues. In addition to being a teacher and an assessment developer, you're also a textbook author. One example is Statistical Reasoning in Sports, *co-authored with Chris Franklin. How did this project come about?*

JT: In the spring of 2009, our high school was looking to create new 4th-year math courses to satisfy revised graduation requirements in the state of Arizona. As a long-time teacher of AP Statistics, and an even longer-time fan of sports, I proposed a course called Statistical Reasoning in Sports. The course would be primarily about statistical reasoning, with the motivational hook of using sports contexts throughout.

Because there was no existing curriculum or standards that I needed to cover, I could teach the course in the best way I saw fit. I could use as much or as little technology as I wanted to. I could teach the course in the traditional order or mix it up. Having so many options is great—but also a challenge. To know how to build the course, I had to identify the principles that I valued most.

I settled on two guiding principles that would inform the way I designed the course:

1. Emphasize that statistics is an investigative process, not a set of isolated skills.
2. Keep focused on the logic of inference.

Historically in K–12 education, statistics has been presented to students as an unconnected set of skills—if statistics has been taught at all. In one course, students might learn how to calculate means and medians. In another course, they might learn how to make a box-and-whisker plot and a stem-and-leaf plot. But these graphs are typically an end in themselves. Because they aren't used to help answer interesting statistical questions, students write them off as tedious and useless. To counter this perception, every unit in the course starts with a question (e.g., Is there a home-field advantage in the NFL?) and we spend the rest of the time learning the skills necessary to answer this question. We learn how to collect the relevant data, how to analyze the data, and how to make inferential conclusions using the data. Yes, we are doing inference during the first week of school, thanks to the power of simulations and randomization-based tests.

The second guiding principle for my course was to stay focused on the logic of inference. I want students to leave knowing that all tests of significance are essentially the same: comparing the observed result with what might happen by chance alone. Using randomization tests helps students keep their eyes on the bigger picture by avoiding the specific technical details that accompany each of the different traditional tests. This makes my course accessible to students—once they learn how to do a test comparing two proportions, they can easily extend the same logic to a test comparing two means, or a test comparing two standard deviations. In a traditional course, these are three very different tests that use three different distributions. In a course that uses randomization-based methods, they are essentially the same test.

Wow—I have been typing for quite a while already and haven't really answered your question. I guess my enthusiasm for these guiding principles got the best of me! Sorry about that—now back to the question. When I was on the AP Statistics Test Development Committee, I had the pleasure of working with Chris Franklin, who was serving as Chief Reader. As many readers of this interview know, Chris was instrumental in developing the GAISE documents that I mentioned earlier. The statistical problem-solving process described in the GAISE document was the inspiration for the structure of what is now our book, *Statistical Reasoning in Sports* (Tabor and Franklin 2013). Of course, Chris did much more than provide this inspiration. She

got us in touch with an editor at a publishing company (Bedford, Freeman, and Worth)—an important first step in the production of a textbook! For the next year, Chris and I were in constant contact, discussing everything from the table of contents to the most minor detail. We went back and forth reviewing drafts and digesting feedback from editors and other reviewers. Chris's experience as an author was invaluable throughout the entire process and she continues to be a great cheerleader for the book wherever she goes. I am incredibly grateful that she agreed to be my co-author!

A couple long years later, *Statistical Reasoning in Sports* was published and is now used in high schools across the country—and even some colleges. It is really exciting to see students getting fired up about statistics because of this book. Many students tell me how they enjoyed the class so much more than any other math course they have taken. But the best compliment about the book I have heard came from a student who didn't know I was listening. He said to his friend "I can't watch sports anymore without thinking about statistics!"

AR: That's a great compliment indeed. I'll also point out that your course/textbook were discussed in a New York Times *article (Schwarz 2011). My next question is a real softball (oh dear, I can't help myself from using sports metaphors) one for you: Can you give us some other examples of sports questions that you tackle (so to speak) in the book? Or perhaps examples of sports questions that your students have pitched (sorry) as project topics?*

JT: The opening chapter asks "Did LeBron choke in the playoffs?" Later in the chapter we also explore the idea of clutch performance. Chapter 3 is all about the "hot-hand" or streakiness in athletic performance. Other interesting questions include "Does the designated hitter increase offense in baseball?", "Do high-tech swimsuits make you faster?", "Which players should I draft for my fantasy league?", "How can we build a better baseball team?", and "When should you go for it on 4th down?" We aren't really trying to discover new knowledge about sports. Instead, we try to ask questions that might capture student interest and also be accessible for an intro-level student.

At the end of each chapter, students do an investigation where they ask (and answer) a question about an athlete or team of their choice. Students really enjoy the chance to do something other than daily homework and tests, especially about a topic they are interested in. And as I teacher I value giving them a different type of assessment—something they can work on over time that helps solidify the statistical concepts we learned that chapter. They have come up with some pretty interesting questions, including "Does Kobe Bryant shoot better after a day off?", "How does team weight affect bobsled performance in the Olympics?", and "Is Tebow-time real?" Even though we live in Arizona, I have discovered that there are lots of Broncos, Lakers, and Yankees fans in my classes!

AR: No doubt many students are strongly motivated by the sports contexts, but do you have any concerns about students who aren't interested in sports? Do you worry that they are missing out on the opportunity to take a non-AP course about statistical reasoning? Or do they take the course anyway, and then are they at any disadvantage for not knowing much about the sports contexts? I realize that many girls are interested in sports, but do you find that the course is taken disproportionately by boys?

JT: We are very fortunate at our school that we offer three different statistics courses: AP Statistics, Statistical Reasoning in Sports, and "regular" Statistics. Students who aren't interested in AP or sports often take the regular course, which is taught with the traditional approach.

In the Sports sections, we have always had at least 40% girls. Furthermore, there is no real prerequisite sports knowledge required, other than "winning is better than losing" and "scoring more points than the other team is how you win (except in golf)." Everything else is defined in the book when needed. In fact, some students proudly tell me that they don't really like sports at all. They took the course because they wanted to learn something that applied to the real world.

AR: Let me ask about your own sports interests. You mentioned that your interest in sports pre-dates your interest in statistics. What sports initially captured your interest, either as a spectator or participant? Where are your sports interests now?

JT: Baseball has always been my favorite sport. Before moving to Arizona in 2nd grade (1980), I lived in St. Louis and my family loved Cardinals baseball. The Cardinals were very exciting in the early to mid-1980's, which helped fuel my interest. I also got really into collecting baseball cards. And much to my wife's dismay, I still have most of them. ☺ During college, I moved on from baseball cards to fantasy baseball. Of course, in the early 90's fantasy sports were much different. There weren't internet sites that did all the work for you—we had to get copies of Baseball Weekly and enter the statistics for each of our players by hand. My favorite part of the process was preparing for the draft, which allowed me to use some of the statistical techniques that I was learning about. Nothing fancy (mostly z-scores), but it did inspire the lead example in Chapter 8 of *Statistical Reasoning in Sports* ("Which players should I draft for my fantasy team?") and question #1 on the 2011 AP exam. These days I am still a big baseball fan (Go Angels!), but don't dedicate nearly the same amount of time as I did when I was single and childless.

AR: Some critics of the use of statistics to analyze sports complain that statistical analyses take the fun out of sports. Do you think your interest in sports statistics enhances your enjoyment of sports, or detracts from it, or has no impact?

JT: Some of both, actually. On the down side, it is often hard to listen to broadcasters who make too much of small sample sizes: "Don't let player *X* pitch to player *Y* in this situation! With two outs and runners in scoring position in the seventh inning of games on the road in domes, player *Y* is batting 0.500 against pitcher *X* (Player *Y* has 1 hit in 2 at-bats).* Or people who criticize coaches for breaking tradition: "I can't believe it! Everyone knows you always punt on 4th down if there is more than one yard to go."

> * Many people think this type of analysis is due to the rise in sports analytics. Rather, I believe that the rise of statistical thinking in sports is confounded with better access to this type of situational data. Both have been increasing simultaneously, so it's easy for a casual observer to make a causal conclusion.

What appeals to me is that many interesting questions about sports can be addressed with statistical analysis. I love to learn new things, and I enjoy watching and reading about sports. The rise of sabermetrics* during my lifetime has allowed me to combine these interests and definitely make sports more fun. I'm sure not everyone shares this opinion, but I'm thankful that many people do!

> * Bill James has defined sabermetrics as the search for objective truth in baseball.

AR: This might be a good time to let readers know about this asterisk technique you're using for tangential remarks. These have been called Posterisks when used by my favorite sportswriter, and one I know that you also admire, Joe Posnanski. That was a tangential remark of mine, I suppose, but now back to the topic of teaching statistics: In addition to the focus on sports applications, your emphasis on the logic of inference is another distinctive feature of your course and textbook. You introduce students to p-values and statistical significance in the very first chapter, by using simulations of binomial processes. How do you try to ensure that students develop a genuine, conceptual understanding of the logic of inference, as opposed to more rote, procedural learning? And how well do you think students are achieving this goal?

JT: Yes, we are making inferential conclusions starting in the first week of school! Randomization-based methods allow us to estimate *p*-values and make inferential conclusions without having to know anything about Normal distributions. Because the inferential piece fits so naturally as the last step in the statistical process, students never wonder "why are we doing inference so early?" In fact, they find it strange when I tell them that my AP students won't be learning about *p*-values for five months!*

> * Actually, I use randomization-based methods in my AP class as well, even though the AP curriculum is much more traditional. During the first semester, we do several activities that conclude with randomization tests (but without the formal vocabulary). During the second semester, I try to introduce each major inference procedure with the equivalent randomization test.

To help students focus on the logic of inference, I approach each statistical question using the same framework. We look for evidence and then use simulation to determine if the evidence is convincing.

For example, in Chapter 1 the lead question is "Did LeBron James choke in the playoffs?" The first step is to find evidence to support the claim that LeBron choked. The example in the book looks at LeBron's three-point shooting percentage in the 2008 playoffs, which was lower than his three-point shooting percentage in the regular season. It appears that LeBron's ability to make a three-point shot went down in the playoffs. But is the evidence convincing? To answer this question, we consider what I call the "two explanations" for the evidence. One explanation is that LeBron's ability to make a three-point shot really did go down in the playoffs. The other explanation is that LeBron's *ability* to make a three-point shot stayed the same, and the decrease in his *performance* was due to *random chance*.*

> * I used the three italicized words in the sentence above for a very specific purpose, as they are the three components of the model we use for athletic performance in *SRIS*:
>
> Performance = Ability + Random Chance
>
> In this model, Ability is the parameter and Performance is the statistic. LeBron's Ability to make a three-point shot is his three-point percentage in an infinite number of attempts, all in the same context. This means that Ability is always unknown. LeBron's Performance is his observed three-point percentage, which can vary from his Ability because of Random Chance.

By using spinners (and eventually applets), we explore what can happen by chance, assuming LeBron's ability to make a three-point shot is the same as the regular season. Finally, to determine if there is *convincing* evidence that LeBron's ability went down, we compare LeBron's actual performance to the performances that could happen by random chance alone. In this case, the evidence that LeBron choked wasn't convincing.

By the end of the class, I think my students have a good sense of the logic of inference. I can't promise that they all will be able to interpret a *p*-value correctly, but I know that they are very aware of the role random chance plays in sports (and other contexts). Part-way through the year, they don't even wait until I finish asking a question—they interrupt with "aw, it could just be random chance." And I smile.

Textbook Writing

AR: Let me ask now about another textbook project, The Practice of Statistics*, co-authored with Daren Starnes, Dan Yates, and David Moore (2015). This book is written specifically for AP Statistics courses, right? How did you come to be involved with this?*

JT: Like you said, *The Practice of Statistics* (*TPS*), now in its 5th edition, is written specifically for the AP Statistics course. Here is a brief history: When the AP Exam started in 1997, there were no books written for AP Statistics. Teachers used a variety of college texts, including the book I used: *Introduction to the Practice of Statistics* (*IPS*), by David Moore and George McCabe. A few years later, Dan Yates (a high school AP teacher) proposed the first book aimed specifically at AP Statistics. He took the best parts of *IPS*, adjusted the table of contents to match the AP curriculum, and made the book more accessible for high school students. This was the first edition of *TPS*. Daren Starnes joined Dan to co-author the second and third editions, with Dan retiring after the third edition.

Around the same time I was proposing *SRIS* to the publisher, Daren contacted me and asked if I was interested in working with him on the fourth edition of *TPS*. I said yes, and went from having 0 textbook projects to 2 in a matter of months. That set off a very crazy couple of years! My role with *TPS* 4e was to write the teacher's materials, including the Annotated Teacher's Edition, and give extensive feedback on the major re-write that Daren was taking on. In the 5th edition, I moved up to a full co-author, while keeping my role as the primary author of the materials for teachers.

Now that *TPS* 5e is out, Daren and I have turned our attention to a new project: A major re-write of a book for on-level statistics courses: *Statistics through Applications*, by Starnes, Yates, and Moore. Like *TPS*, Dan Yates initiated this project which added a high school flavor to a classic David Moore text, *Statistics: Concepts and Controversies.* We are very excited about how the work is going so far and hope to have a finished product in the next year or two.

AR: Can you describe for JSE *readers what kinds of activities you spend most of your time on while writing a textbook?*

JT: Surprisingly, a fairly small percentage of my time is spent writing the actual narrative. Prior to writing the narrative, there is quite a bit of time spent planning what the book will look like or what revisions need to be made. For our new on-level book, Daren and I have spent many days and hundreds of emails going back-and-forth on the proposed Table of Contents, learning targets, features to include, and so on. Once I write the narrative for a particular lesson, I send it to Daren and others for an initial review. After revising the narrative, I write exercises and send out the narrative with exercises for another review. Once a chapter (typically 6–10 lessons) is complete, we work on the chapter review materials, including two more sets of exercises. While I am doing this, Daren is working on another chapter in parallel, so I do plenty of reviewing as well. When chapters are "complete," they get sent to a developmental editor, an accuracy checker, and one or two additional reviewers. Based on their comments, we make even more revisions. Then, the chapter goes to a copy editor (more revisions!) and finally to proof-pages, where a compositor combines the text with the design elements. We read through these pages, noting any problems with the layout or other issues. This page-review process goes on for at least three rounds before pages are final. And this is just for the student edition! There is a lot more involved in the production of the teacher support materials, including writing, reviewing, and even filming professional development videos.

AR: Do you think your SRIS emphasis on the entire process of doing statistics and on simulation/randomization-based inference could work effectively in an AP Statistics course?

JT: I definitely think so, but it would take a lot of effort to reconfigure a book to make it work effectively. It is appealing to start with a statistical question in each chapter and then introduce the skills on an as-needed basis. It would be especially appealing to me to break up the big chunk of probability topics that happen in the middle of the course, as this is typically where my kids run into the biggest obstacles. And you know I like using the randomization-based approach to introduce the logic of inference early in the year!

Another challenge would be finding time to cover all of the topics required by the AP exam in an efficient manner. Because the developers of the AP exam wanted to ensure passing scores would be accepted at a large number of colleges, the course covers more topics than a typical intro course. And even though we have more time than a one-semester college class, most AP teachers that I know are pressed for time already.

Pop Quiz

AR: Now let's begin one of my favorite parts of every interview that I've done for JSE*. I call this the "pop quiz," and I'll ask that you limit your answers to just a few sentences. First, please tell us about your family.*

JT: I've been married to my lovely wife Anne for nearly 11 years and we have a seven-year-old daughter Jordan. Jordan has many nicknames, but I know your favorite nickname comes from an ongoing joke I had with my wife when she was pregnant. I suggested that "Anova" was a pretty name for a girl, but when I explained the term to my wife she wasn't amused. In any case, for the first year or two of Jordan's life, she was only known to my statistics friends as Anova. Now she prefers to be called by her full name, Analysis of Variance.

AR: I detect substantial regression in that response. What are some of your hobbies outside of teaching statistics?

JT: Honestly, there isn't much time outside of teaching, writing, workshops, and so on. But when I have time I like to work in my garden. In Arizona, we can grow vegetables and other plants year-round, so there is always work to do. I have four raised-bed planters and hope to run some randomized experiments in the near future!

AR: What are 1–3 books that you've enjoyed reading in the past year?

JT: For the last year, my wife and I have been reading through the New Testament, one chapter per day. With my daughter, my favorite book to read is *Muncha!, Muncha!, Muncha!,* an amusing book about a frustrated gardener. I also re-read *The Hobbit* in preparation for the second movie in the trilogy last winter.

AR: How about movies: what are 1–3 that you've seen in the past year, either in a theater or on video or however?

JT: I don't get to see many movies, but I have managed to see *Frozen* approximately 1 billion times over the last year. And that doesn't count listening to the soundtrack or my daughter singing *Let it go* everywhere she goes. Recently my wife and I watched *Million Dollar Arm,* which was quite fun.

AR: Let's see, that amounts to an average number of Frozen *viewings per day of, well, never mind. What are some of your favorite places that you have traveled?*

JT: I am fortunate to have traveled quite a bit. I have been to 45 of the 50 states and 30 Major League Baseball stadiums (but not all 30 current stadiums). One of my most memorable trips was a five-week trip through Europe with a buddy in the summer of 1998.

AR: What's your favorite airport, and do you prefer aisle or window?

JT: I definitely prefer aisle seats, which probably has a lot to do with my Diet Coke addiction. I don't want to seem too biased towards Arizona, but I really like Sky Harbor in Phoenix. There are almost never any weather delays, the wifi is free, and there are lots of different food choices.

AR: Now let me ask a ridiculous, but I hope fun, question. Suppose that I offer you a dinner for four where you can discuss statistics education to your heart's content. You get to choose your three dining companions and the location for this dinner. Who would you choose, and where would you dine?

JT: Wow—that's a tough one. I am fortunate that I get to chat with many of my top candidates every year at the AP Reading, even if the dinner setting isn't always that great. To make things somewhat easier, I am going to exclude my AP buddies and people I talk with regularly, including my co-authors Chris Franklin and Daren Starnes. Here's my lineup: George Cobb, Dan Teague, and Nate Silver. I've only met George once, but I've been greatly influenced by his thinking on the randomization approach to inference. I'd love to hear what other thoughts he has on statistics education. Dan Teague was an instrumental figure in my early years of teaching statistics. He no longer comes to the AP reading, but many of my "aha" moments were based on things he taught at the reading and other workshops. Nate Silver isn't really known as a statistics educator in the typical sense, but he has done a lot to promote good statistical thinking in a variety of areas. I was reading his work on baseball long before he became famous for his election forecasts.

AR: What is your favorite course to teach?

JT: It's a toss-up between AP Statistics and Statistical Reasoning in Sports. There are great things about both courses. Any traditional math class would be a distant third.

AR: If you weren't a statistics teacher, what profession might you be pursuing?

JT: Probably something related to financial planning. My plan coming out of high school was to be help others with their finances, including budgeting and investments. When I switched to become a math major, it wasn't because I lost interest in financial planning, but rather because I gained a stronger interest in teaching.

AR: I think you've already revealed some surprises in this interview, such as your hair length before your students' first AP exam. Please reveal something else about yourself that is likely to surprise most JSE *readers.*

JT: I don't have cable or satellite and watch sports fairly infrequently. Other than the Angels games I watch online (thanks to mlb.tv) and high school games I attend in person, I tend to spend my few available hours reading about sports rather than watching them.

Collecting Data

AR: Now I'll ask a series of questions on which I sometimes collect data from my students, involving binary, categorical, discrete, and continuous variables. Do you consider yourself to be an "early bird" or a "night owl"?

JT: Can neither be an answer? I prefer to go to bed early and wake up late! If you force me to choose I will say "night owl" because it is harder for me to get up early than stay up late.

AR: Do you use a Mac or PC?

JT: PC.

AR: On what day of the week were you born? (You can use www.timeanddate.com to produce a calendar for your birth year.)

JT: Thursday.

AR: How many Harry Potter *books have you read?*

JT: None. Although I have read *The Lord of the Rings* three times!

AR: How many miles do you live today from where you were born? (You can use www.distancefromto.net to calculate this distance.)

JT: 1243 miles from Oro Valley to St. Louis, Missouri.

AR: Here's another question on which I collect data from students, a fanciful one: Suppose that time travel were possible, and you could take one trip. You can only observe, not change anything, when you get there. Would you travel to a time in the past or in the future? Why?

JT: My students would want me to travel to the 2015 AP reading, memorize the rubrics, and report the results. Assuming that I could overcome the language barrier (which seems perfectly reasonable if we have figured out how to travel through time), I would love to travel back to the time of Jesus. There is a lot written about the major events of his life in the New Testament, of course, but not much about how he lived from day-to day.

Parting Thoughts

AR: One intriguing aspect of your career that I have not yet asked about is that you're now teaching at your alma mater. How did you come to return to the school that you graduated from? Does it seem very familiar and comfortable, or is it a weird feeling to teach in the same school at which you were a student?

JT: I love teaching at my alma mater, Canyon del Oro High School (CDO). My alumni status helps me connect with my students—and I get to wear my old letterman's jacket every once in a

while. Because I spent 4 years in college and 12 years teaching in California, there was quite a gap between my time as a student and my time as a teacher. In fact, when I came back to CDO only five of my teachers were still on staff, so there weren't many weird feelings. Now, only one of my teachers is still around (Hi Mr. Yetman!). There have been some nice improvements on campus, but I am quite certain that many of the desks I sat in as a student are still in use today.

AR: In what sport(s) did you earn a letter?

JT: Cross country and track. I wasn't very fast, but I enjoyed distance running. In the final race of my high school career, I ran the 1600 meters in 5 minutes flat. I was trying to break the 5-minute barrier, but fell just short. Now I would be happy to finish the 800 in 5 minutes. ☺

AR: One of my standard end-of-interview questions is to ask about which achievement in statistics education you're most proud of. But I realize that you're probably just now approaching halftime of your teaching career. So, let me ask two questions: What professional accomplishment are you most proud of at this point in your career? And, what do you most hope to achieve by the end of your career?

JT: Halftime seems about right—I definitely feel like I need a rest! So far, I think my proudest accomplishment is the development and publication of *Statistical Reasoning in Sports*. Seeing it in print after years of labor was amazing. And knowing that it is being used all over the country to help students learn about statistics is even better.

Looking ahead, I am not sure what I hope to achieve. Six years ago the prospect of writing a book wasn't even a consideration and now I am working on a third book project. To be perfectly honest, I feel blessed to be in the place that I am right now, teaching classes, leading workshops, and writing textbooks. I hope to continue doing these same things for as long as I can.

AR: Thanks again, very much, for taking the time to answer all of my questions. As a preface to my final question, I want to point out that you're the first high school teacher whom I've interviewed in this series. I believe that a large majority of JSE *readers are college and university faculty members. Many of these professors dedicate a substantial portion of their careers to preparing future high school teachers, and many more teach students who have studied statistics to some extent in high school. My final question is quite open-ended: What do you want to say to these professors about the teaching of statistics at the high school level?*

JT: As I said at the very beginning of the interview, I am honored that you chose me to interview for the *Journal of Statistics Education*. I hope that my answers have been interesting to your readers! Leaving high school in 1991, I had no idea what statistics was all about. In 2014, over 185,000 students took the AP Statistics exam, and even more took a course in statistics at their high school. Many of these students arrive on your campus with an interest in statistics, but without knowledge of how to pursue this interest. It would be great if readers could reach out to the AP Statistics students in your area to give them information about future courses in statistics, or even majoring in statistics!

The most important message I want to send is captured by a statement from my ICOTS presentation this summer (Tabor 2014): With the implementation of the Common Core State Standards in the United States, *all* teachers of mathematics in grades 6–12 will also be teachers of statistics. In the past, statistics has been a small part of the school curriculum, other than stand-alone classes like AP Statistics. As a result, many freshly-minted math teachers came from college with little or no statistics training. I know that this is changing at many institutions, but I encourage readers to make sure their school requires at least one intro-level statistics course (not mathematical statistics) in their teacher-preparation programs.

I would also encourage readers to reach out to *current* middle- and high-school teachers who didn't get statistical training in college. Offer workshops that give teachers an overview of the probability and statistics standards in your state, along with plenty of activities and examples teachers can use in class. We need all the help we can get!

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