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The Editor's Corner

Angela Walmsley

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Welcome back to school! It's so much fun to see photos and hear of back-to-school stories, which seem to take place from July through the end of September in the United States! I hope this edition of the *Statistics Teacher Network* finds you well, back in the groove of your classroom, and that it contributes to your statistical teaching this year.

The first article is by **Matt Teachout**, a math teacher and statistics coordinator at College of the Canyons—a large community college in Santa Clarita, California. I'm personally thrilled to see this article in the *Statistics Teacher Network* because we often don't have authors from community colleges. Matt describes the situation facing many community colleges, which is the focus away from a predominantly algebra-driven curriculum to a statistics one. He also provides a rationale for why we are seeing this change and tips for teachers in community colleges also making this statistics education–focused change.

The second article is by **Allison Dorko**, a doctoral candidate in mathematics education at Oregon State University. The topic is the investigation of Double Stuf Oreos and whether they actually have double the stuffing of regular Oreos. Allison does a nice job of explaining how she uses this topic in her high-school classes involving inferential statistics. As a modification, she also describes how to take the same topic and analyze it in a middle-school setting.

The third article, by **Leah Dorazio** at San Francisco University High School, describes a pertinent topic for all teachers of inferential statistics: the significance (no pun intended) of the *p*-value = 0.05. Leah does a great job of showing two examples of activities students can do in class that will lead them to better understand why the "standard" *p*-value is around 0.05.

I encourage you to read all these great articles! All have information that can be used directly in the classroom at various levels.

We encourage our readers to write for the *Statistics Teacher Network*! We love to publish a variety of articles about statistics throughout the pre-K–16 range. Our editors are also happy to assist if you have an idea for an article. Please send any articles or ideas you have for consideration to *Angela.Walmsley@cuw.edu.*

Regards,

Angela Walmsley, Editor
Concordia University Wisconsin

Articles

Helping Community College Math Instructors Teach Statistics Effectively

By Matt Teachout, College of the Canyons

We are reaching a crisis at community colleges across the country. The number of STEM majors (science, technology, engineering, and mathematics) has dramatically decreased, while the number of non-STEM majors continues to rise. At my college alone, only about 30% of our students are STEM majors.

The Problem

Here is the problem as I see it: The traditional math curriculum is geared toward calculus preparation for STEM majors. Non-STEM students do not need to follow a traditional college mathematics track because they do not need calculus. They need real-world critical thinking skills and the ability to deal with a changing world in which unlimited data are a click away.

In short, our students need statistics.

Not just for their degree, or for transferring to a four-year institution, but for real life. In a sense, our mathematics education system seems backward: We teach an unending amount of algebra classes, but few statistics classes. This system is out of date, and we are not meeting the demand of our students.

The Results

At my college, we are experiencing a huge shift from an emphasis on algebra to one on statistics. This is a shock to many community college math departments. Community college math teachers make their living teaching students basic algebra. Now, they are being asked to move into pre-statistics and statistics and teach a subject many were never trained for.

Data from my college made it apparent that we were placing students too low. Many students have the ability to succeed in the 100-level Intro Stats course and should be allowed to take it. Not only do they not need algebra classes as a prerequisite, but many do not even need the pre-statistics class. At my college, we are anticipating a large increase in the number of sections of our 100-level Intro Stats course over the next few years because of the de-emphasis on algebra and increased emphasis on statistics.

Damage Control

Statistics has historically not been a popular class with math teachers. At my college, we don't want to simply get a teacher in the room; we want our Intro Stats courses to rock! We want high-level critical thinking and deep conceptual understanding. How do we do this effectively?

Activity-based pedagogy, statistics software usage, an organized teaching schedule, and support and training for teachers when needed are vital.

1. Activity-Based Pedagogy

We need to make Intro Stats easier to teach. My college has been using activity-based pedagogy (active learning) with an emphasis on the affective domain for many years. Instead of relying on a math teacher to explain every detail in a rigorous statistics textbook, the activities teach the topics. Intro Stats needs to be topic-driven, not book or lecture driven. There is less pressure on the teacher to explain everything, and students learn the material much better by actively working with data. In many ways, the classroom has been flipped. After a set-up lecture, students work with data to learn the concepts and solve problems. The teacher is the facilitator who is there as a guide to lead the students to understanding.

2. Use Technology

We are in the Big Data age. We need to make our students real-world critical thinkers. They can't analyze data sets with thousands of numbers without computers. It is vital that we teach students how to use high-powered statistics software. If you have access to computer labs, stop using *p*-value charts and calculators to calculate sample statistics. Teach your classes with technology. Statistics is a visual subject. Students have to be able explore a data set and see how statistics works.

I understand these are challenges if you teach in a school that does not have computer labs or funding for computers. Sadly, most Intro Stats and AP Stats classes across the country have little to no technology. Ask most students who have taken Intro Stats or AP Stats and they will tell you the point of the class was to use hard formulas to calculate things. No! Those students have totally missed the point.

If you want high critical thinking and deep conceptual understanding from students, they need access to statistics software. If you have taught Intro Stats or AP Stats without technology, you probably think—as I did for many years—that there is way too much material to teach in such a short time. That is because we are not teaching it as well as we can. Students need to experience how statistics works and practice working with data. Statistics is like tennis. Without technology, all we can do is describe what a racket looks like and the various ways to hit the ball. We can describe the rules of tennis, but students can never hold the racket themselves and hit a ball.

So what can you do to incorporate statistics software into your classroom if you are at a school with few available computer labs?

Here's what I did.

Look around your school and see if there are times when computer science courses are not using a computer lab. Some colleges have a surprising number of empty computer labs that are only used a couple times a day. Book your statistics classes at those times in those rooms, or at least see if you can reserve the room once a week or once a month.

If you only have access to one computer (maybe your own laptop) and a projector of any kind, project the statistics software on screen and analyze real data with your students. Focus on having them interpret and understand the major concepts. On exams, give printouts of statistics software displays and write test questions to check for understanding. You can also pass out printouts of the graphs and statistics and have your class work on conceptual understanding. While this is a poor substitute for the real thing, it is a step in the right direction.

You may want to also incorporate technology into your textbook. In place of a traditional text, I recommend online courseware through OLI (Open Learning Initiative). The courseware is an open educational resource in conjunction with OLI at Stanford and Carnegie Mellon universities. I like to use material from *Concepts in Statistics* and *Probability and Statistics* in my classes, but *Statistical Reasoning* is also available.

OLI courseware is self-grading, with instant feedback for teachers. It shows students interactive graphs, applications, and videos designed to teach topics quickly and more efficiently than complex written descriptions. OLI focuses on high-level conceptual understanding, not practice problems and calculations. If you are interested, OLI courseware is available at *http://oli.cmu.edu*.

3. Give Teachers Structure and an Organized Schedule

We like to give our math instructors a detailed daily schedule, outlining exactly what they will be teaching. Each day, our teachers facilitate discussions and activities designed to help students understand a major concept. Detailed directions and teaching notes assist teachers with the major ideas and how to use the technology. The key is that students need to see the forest during class, not understand every tree. Those details come through working with statistics problems outside of class.

4. Give Training and Help When Needed

Math teachers need a lot of support to teach Intro Stats well. Professional development with full- and part-time math faculty is critical. Math teachers need practice with the technology and activities to be effective facilitators in the classroom. I always recommend our new teachers work through materials themselves.

I have found that “experienced” Intro Stats teachers need training also, especially on how to use statistics software effectively. For example, they may know the words of the Central Limit Theorem, but may have never used software to create a sampling distribution and explain all the implications of the Central Limit Theorem with real-data examples.

Deans and department chairs may be wondering how to train 50–100 community college math teachers to teach statistics. It is never going to happen. There are way too many statistics courses to staff. Here is the way I would approach it:

- Sign up the math teachers to teach Intro Stats, even if they have no experience.
- Give the math teachers access to the book and statistics software so they can work through the book and play with the software.
- Give the math teachers a detailed schedule of what activities to teach each day.
- At the start of the semester, have the new teachers attend a meeting/training. At the training, a more experienced teacher will explain the major ideas addressed in the first couple weeks, where students will get stuck, and how to use the software and activities effectively. After two or three weeks, have them attend another training or meeting. Continue this process throughout the semester.

A structured course based on technology and activities will still be a high-quality Intro Stats course for students, even if the teacher is still learning. Once the instructors get through their first semester, the biggest hurdle is over. I like to tell my Intro Stats students that the study of statistics is like a deep well, full of water, and they are only playing in a puddle.

So What Now?

How do we tell the thousands of math teachers that community colleges are being overrun with the need for statistics classes and desperately need math instructors to take on the challenge of teaching statistics? For me, it comes back to my students. Thousands of students across the country have failed out of community colleges because they could not complete algebra courses they never needed in the first place. Students today live in a technology- and data-driven world. They need statistics, not only for their degrees, but to begin to understand the world around them.

Double Stuffed?

By Allison Dorko, Oregon State University

In 2013, a New York high-school statistics class made national news when they investigated whether Double Stuf Oreos truly had double the "stuf." They took filling from 10 regular Oreos, massed it as one gob, and divided by 10. They did the same with the Double Stuf cookies. The students divided the mean mass for the Double Stuf by the mean mass for the regular cookies and got 1.86, indicating that the Double Stuf cookies did not have double the filling.

The question of whether Double Stuf Oreos actually have double the filling is an intriguing one. In this article, I describe an activity that uses that question as a hook to engage students in finding means, comparing distributions, and performing *t*-tests. While the New York class' method is perfectly valid, I like my version of the activity because it incorporates more mathematical content. At the end of the article, I provide an adaptation appropriate for middle-school students.

I suggest using the Double Stuffed? Activity (**figures 1 and 2**) after students have learned how to conduct *t*-tests for two independent samples. As such, prerequisite knowledge includes how to make a histogram, compute means, and compute standard deviations. Students should also know how to perform and interpret a *t*-test for two independent samples and the assumptions underlying the test. (These prerequisites correspond to Common Core State Standards for Mathematics 6.SP.1, 6.SP.2, 6.SP.5, 7.SP.3, 7.SP.4, S-ID.1, S-ID.2, S-ID.3). I like to form the statistical questions and a plan for data collection as a class, then have students divide into small groups to collect data.

High-School Lesson Plan

The first step in the activity is forming a statistical question. Here's what we really want to know:

> Is there evidence that the mean amount of filling in Double Stuf Oreos is twice the mean amount of filling in regular Oreos?

However, we cannot start with this question, because it assumes Double Stuf Oreos have more filling than regular Oreos. This is a reasonable assumption to make, but it is also one for which we can provide empirical support. Hence I ask students how they could use statistics to establish whether the two types of cookies have different amounts of filling. I pose the question, "How could we establish that Double Stuf Oreos and regular Oreos have different amounts of filling?" If students have been studying *t*-tests, they should respond with "a *t*-test!" They might suggest comparing the means, to which you could respond, "What is a statistical method for comparing means?" Students should settle on a *t*-test for independent samples because we wish to compare whether two groups (filling from regular Oreos; filling from Double

Figure 1. Materials

- Two packages of Double Stuf Oreos
- Two packages of regular Oreos
- 4 to 6 kitchen scales or beam balances
- 12 to 18 muffin papers (2–3 for each group)
- Plastic knives
- Bowls or paper towels (to hold deconstructed cookies)
- Paper, pencils, and calculators (for data collection and calculations)

Stuff Oreos) have different means and the two groups are independent because they are two types of cookie. I suggest writing the two questions of interest on the board:

1. Is there evidence that Double Stuf Oreos and Regular Oreos have different amounts of filling?

2. Is there evidence that the mean amount of filling in Double Stuf Oreos is twice the mean amount of filling in regular Oreos?

The next step is to ask students, "What are the null hypotheses for Question 1?" It may help to remind them that null hypotheses tend to state that there is no difference from the mean. For the alternative hypothesis, ask students if they think a one- or two-tailed test is more appropriate. They should say a one-tailed test because there is a direction of interest: It is reasonable to assume Double Stuf cookies have more filling. Students should settle on something like the following:

$$H_{01}: \mu_{\text{DoubleStuf}} - \mu_{\text{Regular}} = 0$$

$$H_{A1}: \mu_{\text{DoubleStuf}} - \mu_{\text{Regular}} > 0$$

Now your class is ready to collect data. I suggest taking the time to let students offer ideas, as it provides a chance to talk about what ideas will generate the data needed for the *t*-test. (See Figure 2 for my suggested procedure.) Students need to settle on a procedure that gives the mass of the filling from each individual cookie, because this allows them to compute a standard deviation. In my experience, some students suggest scraping the filling from all the cookies, massing it all at once, and dividing by the number of cookies. While this will give them a mean, they will have no way to compute the standard deviation.

Have students follow an agreed-upon procedure similar to that in Figure 2. Now they have data and histograms! Ask students if the assumptions for the *t*-test are met. The samples are independent because they are two types of cookie. Check the normality assumption by examining the histograms. In my experience, the data tend to be normally distributed. Hence we can perform the test. Have the class agree upon an alpha level, then have each student run the test using computer software or by hand.

Students should find a *p*-value such that $p < 0.05$. I ask them what this means in terms of the hypotheses. They should compare the *p*-value to the alpha level and decide that since $p < \alpha$, we should reject the null hypothesis. I ask what this means in terms of the cookies. They should say we have evidence that Double Stuf Oreos have more filling than regular Oreos.

How do we test whether Double Stuf Oreos have double the filling? Students will likely suggest multiplying the regular filling masses by two and running a *t*-test. Ask them to write the null and alternative hypotheses. Remind students the null hypothesis is that there is no difference between the two means.

Figure 2. Data-collection procedure

1. Divide the cookies among the groups so each group has some regular Oreos and some Double Stuf Oreos. As a whole, the class should have at least 30 of each type of cookie.
2. Zero the scale.
3. Find the tare weight of a muffin paper.
4. Scrape the filling from one cookie into the muffin paper. Record the mass of the muffin paper and cookie.
5. Subtract the mass of the muffin paper and record the filling mass.
6. Repeat steps 4 and 5 for all of your cookies.
7. Record your data in a class data table.
8. Create a histogram for the class data for the regular Oreo filling masses.
9. Create a histogram for the class data for the Double Stuf Oreo filling masses.

In this case, our two means are the experimental mean of the Double Stuf filling masses and the mean of our regular filling masses, multiplied by two. In the alternative hypothesis, we want a two-tailed test because we do not know if the Double Stuf cookies have less than twice the filling, twice the filling, or more than twice the filling as the regular cookies. Hence the hypotheses are:

$$H_{02}: \mu_{\text{DoubleStuf}} - \mu_{2\text{Regular}} = 0$$

$$H_{A2}: \mu_{\text{DoubleStuf}} - \mu_{2\text{Regular}} \neq 0$$

Have students multiply each regular filling mass by 2 and compute the new mean and standard deviation, set an alpha level, then run the test. My data sets have always found $p > 0.05$, meaning we fail to reject the null hypothesis that there is no conclusive difference between the filling masses for regular and Double Stuf cookies.

However, there is a caveat with how we performed our test. Ask students to compare the standard deviation of the 2xRegular data to the standard deviation of the Regular data. What happened? Students should observe that the standard deviation increased. In particular, it doubled. Now ask students to compare the standard deviation of the 2xRegular data to the standard deviation of the Double Stuf data. In my experience, the standard deviation for the 2xRegular data is greater than the experimental standard deviation of the Double Stuf (e.g., $\sigma_{\text{DoubleStuf}} = 0.14$, $\sigma_{2\text{Regular}} = 0.21$). Ask students why this might be important. The answer lies in the manufacturing process. While the machine that puts filling in the Double Stuf cookies does not put the exact same amount of filling in each cookie (which we can see from our data), the variance for our 2xRegular data is much larger than the experimental Double Stuf standard deviation. It is important that students note that our method is not perfect, as it assumes more variation than likely exists. This discussion is a nice way to highlight the limitations of a mathematical model.

Middle-School Lesson Plan Modification

Middle-school students can explore the Double Stuffed? questions stated above by comparing the shape, center, and spread of the two filling distributions. Students should follow the procedure outlined in **Figure 2**, then compute the mean and range for each data set.

Regarding the first question, whether Double Stuf Oreos have a different amount of filling than regular Oreos, students might notice the two distributions do not overlap (this is also evident in that the ranges do not overlap). They might also notice that the mean of the Double Stuf filling mass is about twice that of the mean of the regular filling mass. If students struggle in answering this question, I suggest asking them to compare the center and/or spread of the distribution. This helps them focus on comparing means and/or ranges, respectively.

Once students have agreed that the two types of cookies have different amounts of filling, ask whether they think the Double Stuf cookies have double the filling. Students might say yes, because the mean of the Double Stuf filling mass is about twice that of the mean of the regular filling mass. Others might say no, because not all of the Double Stuf filling masses are double the mass of the regular. For instance, in some of my own data, there are some regular filling masses of 3.2 g and 3.3 g and some Double Stuf masses of 5.8 g and 6.0 g. Lead students in a discussion about variation, pointing out that while not all the Double Stuf filling masses are double the mass of the regular cookies, it seems that, on average, the Double Stuf cookies do have double the filling. (This has been my conclusion; your data sets may vary). While these students may not continue with the statistical *t*-test, the activity provides a nice way for them to analyze real-life data descriptively and make assumptions prior to testing knowledge.

I hope your students enjoy this use of mathematics to answer a real-life question. They will certainly enjoy eating the data source!

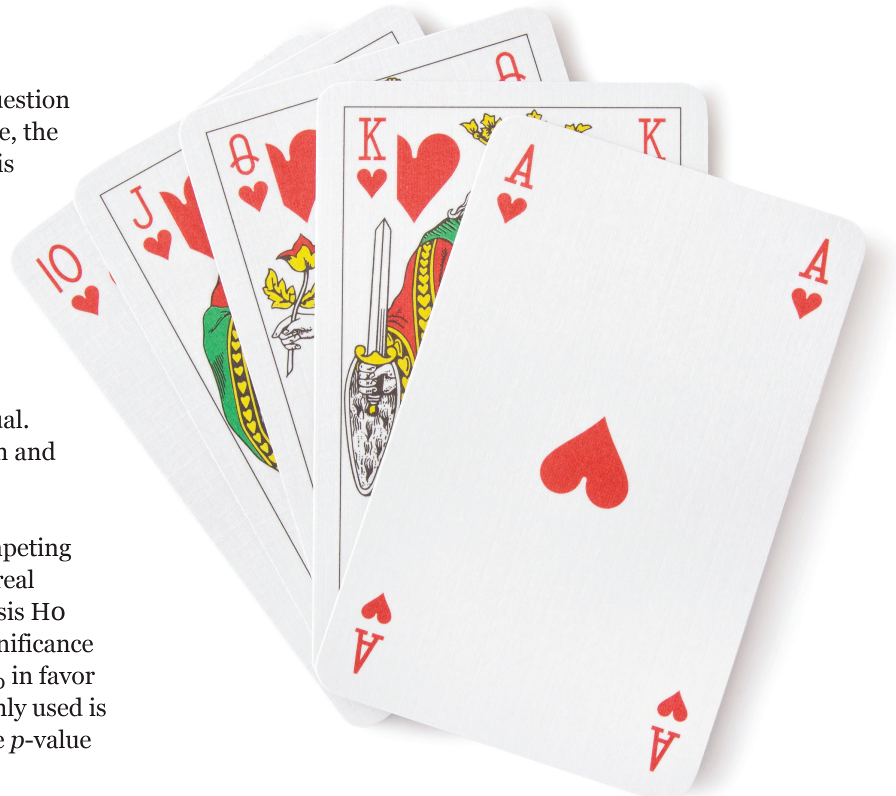
Further Reading

www.cnn.com/2013/08/21/us/oreo-high-school-experiment

blog.recursiveprocess.com/wp-content/uploads/2013/03/IMG_0996.jpg

Why 0.05? Two Examples That Put Students in the Role of Decision Maker

By Leah Dorazio, San Francisco University High School



Any teacher of Introductory Statistics has heard this question more times than they can remember: “Why 0.05?” Here, the value 0.05 refers to the significance level in a hypothesis test. A nice overview of hypothesis tests is described in the Fall/Winter 2015 issue of STN.

In this article, I provide a brief review of the concepts of hypothesis test and significance level. Then, I describe two activities for teachers to proactively address the question of why 0.05 with their students, one tactile and numerical and the other online and visual. These activities challenge students to use their intuition and probability sense to make their own decisions.

In a hypothesis test, there are competing claims, or competing hypotheses. The alternate hypothesis H_A asserts that a real change or effect has taken place, while the null hypothesis H0 asserts that no change or effect has taken place. The significance level defines how much evidence we require to reject H_0 in favor of H_A. It serves as the cutoff. The default cutoff commonly used is 0.05. If the p-value is less than 0.05, we reject H_0. If the p-value is greater than 0.05, we do not reject H_0.

But why use a cutoff of 0.05? An interesting look back at the thinking of the founders of hypothesis testing is described in a 2013 article in the magazine *Significance*, but that complicates the issue rather than explains it. A simple response might be to say that it is merely a rule of thumb or a mutually agreed upon value within the statistical community. Students are not satisfied with this answer. One might go on to assert that a value two standard deviations away from the expected is considered unusual. To connect this to the logic of hypothesis testing, as the probability of an event falls below 5%, we become more and more surprised if we witness it occurring. Students get this logic, but they still want to know why 0.05 and not some other number.

The first example involves my favorite way to introduce hypothesis tests and their corresponding logic. The basic idea is described by Stephen Eckert in the *Journal of Statistics Education* (1994). I have heard of slightly different versions from various teachers over the years. It goes like this. Buy two decks of cards. Create a modified deck of cards that contains all red cards. In class, present the students with a game based on the color of the cards drawn. As an example, say that the first student who draws a black card will get \$10. Randomly pick students one by one and have them select a card, showing the card to the class. Put the card back into the deck and reshuffle. (This is important—once, I did the drawing without replacement and two students both got a red Jack of Hearts!). After three red cards are drawn, students will get increasingly excited, thinking that they might be the winner; they are not yet suspicious. One by one, they continue to draw only red cards. Four red cards in a row, five …

At this point, you will begin to hear a lot of grumbling and questioning if the deck is rigged. With an exaggerated show of being offended, ask, “Why would you say that?”After a few responses, someone will eventually say, “Because if the deck were fair, it’s really unlikely that we would get five red cards in a row.” Exactly. Now they have experienced and verbalized the logic of hypothesis testing on their own.

At this point, we can investigate the probabilities. If the deck were fair (p=0.5), the probability of getting four red cards in a row would be:

$$(1/2)(1/2)(1/2)(1/2)=(1/16)=0.0625$$

This is where students start to get suspicious, but will not yet denounce you. If the deck were fair (p=0.5), the probability of getting five red cards in a row would be:

$$(1/2)(1/2)(1/2)(1/2)(1/2)=(1/32)=0.0315$$

And yes, at this point, students will be arguing that the deck is unfair (that is, rejecting the null claim of a fair deck). These calculations serve as a first pass in explaining why a cutoff or significance level of 0.05 is reasonable. It is around where our natural suspicion starts to kick in.

There are many variations on how to carry out this demonstration and how to wrap it up. I stop after five draws, saying that I want to stop while I'm ahead. If you continue, students will become too certain that the deck is unfair. With five draws, there is still doubt. At this point, students can choose to believe the deck is unfair or they can choose to believe they were just unlucky. Students will, of course, want to see the deck, which you should by no means show them. As I tell my students—the whole practice of statistics is dealing with uncertainty; there are no correct answers against which you can check the decisions you make. I like to put one black card in the deck. At the end, I will say, "I cannot tell you whether the deck is fair or unfair, but …" and I show them the black card. This gives them a shock and makes them reconsider their conclusion based on this new evidence. If you want to really confound the students, steam open one of the new decks, and, after creating the modified deck, carefully reseal it. This way, you can make a big to-do of showing the class it is a brand new deck (thus increasing the threshold of suspicion).

The second example comes from *openintro.org*, a group (for which I am a volunteer) that produces free and open-source statistics resources, including introductory statistics textbooks and TI and Casio graphing calculator tutorials. Instead of approaching the why 0.05 question from a quantitative angle using a one-sample test for proportions, it approaches it from a visual angle using scatter plots and the hypothesis test for a significant linear relationship. The activity can be found at *openintro.org/stat/why05*. After an introductory video, the visitor is presented with a series of 15 scatter plots (three of which are shown in **Figure 1**). For each one, they must decide whether the graph provides enough evidence of a real, upward trend or not enough evidence for a real, upward trend; that is, whether they reject H_0 or do not reject H_0. After completing this task, a follow-up video explains the results and then the visitor is presented with their individual results based on the choices they made for the set of scatter plots. Each graph has an associated *p*-value for the test on the slope of the regression line.

Now the "Aha!" moment. The next screen reveals all 15 graphs with their associated *p*-values, and for each one whether the visitor rejected Ho or did not reject Ho based on their intuition and their visual inspection. I did this activity, and, as seen in **Figure 2** the cutoff for me was 0.06! This means I found evidence for a significant linear relationship for the graphs that had an associated *p*-value less than 0.06 and did not find evidence for a significant linear relationship for the graphs that had an associated *p*-value greater than 0.06. Of course, each individual's cutoff may vary. This activity is great to do in class (the videos can be skipped, with the teacher filling in the

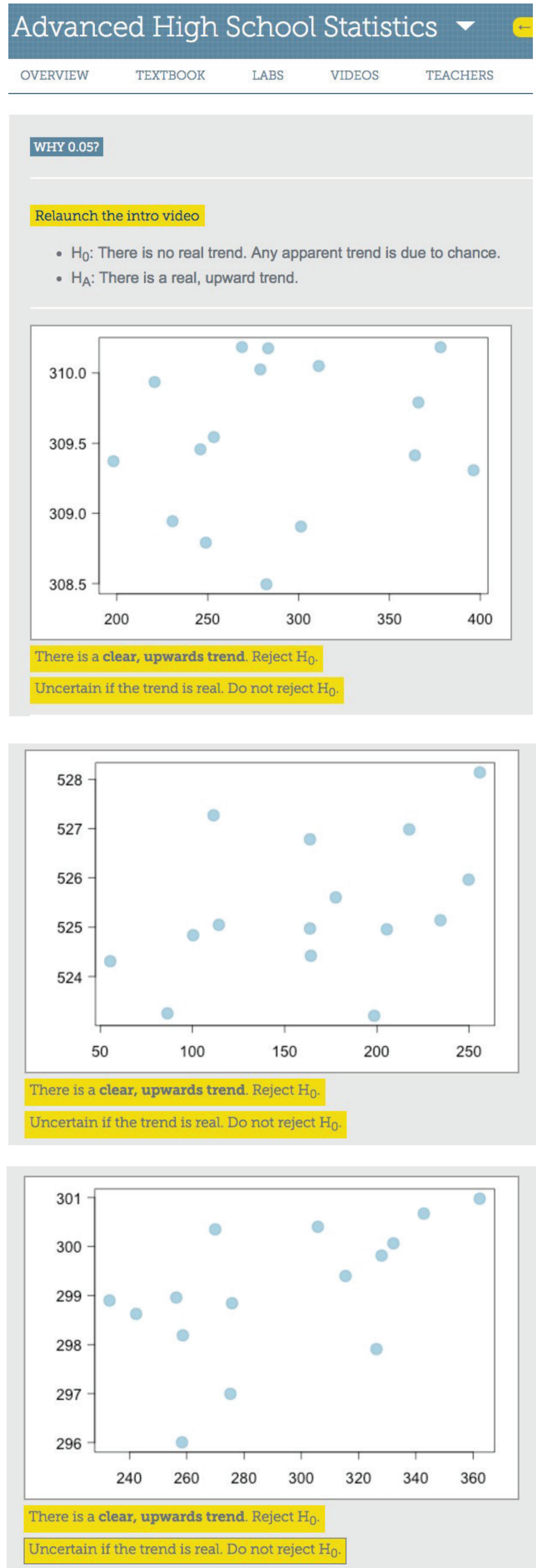


Figure 1: Three plots from *openintro.org/stat/why05*

necessary explanation). When all the students finish, make a dot plot of the cutoffs each student (subconsciously) used and find the class average. You will find that this value is consistently close to 0.05!

There are limitations to focusing too narrowly on the *p*-value. The ASA recently published a statement on *p*-values, stating: “Well-reasoned statistical arguments contain much more than the value of a single number and whether that number exceeds an arbitrary threshold.” As teachers, we must also address issues of experimental design, the question of causality, and the true interpretation of *p*-value. Nevertheless, these two introductory examples serve to provide students with a strong understanding of the logic of hypothesis testing and a sense of why 0.05 is a reasonable default significance level to use. If a problem does not indicate what significance level to use, students can be allowed to use either their individual cutoff value from the activity or the class average (assuming these are reasonable values). By engaging students in deciding for themselves how much evidence is enough evidence, they come to better understand that evidence presents itself along a continuum, even though, at the end of the day, a decision must be made.

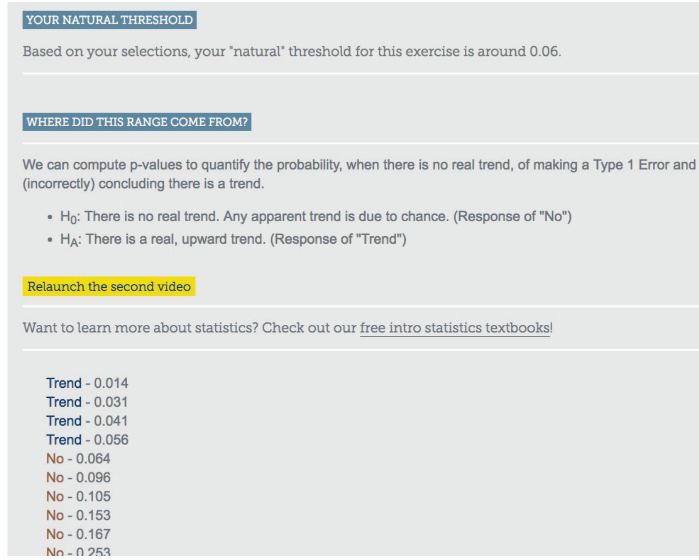


Figure 2: My results from *openintro.org/stat/why05*.

Further Reading

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Kelly, M. (2013). Emily Dickinson and monkeys on the stair; Or: What is the significance of the 5% significance level? *Significance*, 10(5), 21-22.

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Mehmet Türegün (2013). Modeling statistical significance. *Intersection Points: The Newsletter of the Research Council on Mathematics Learning*, 37(3).

Diez, David M.; Christopher D. Barr; Mine Çetinkaya-Rundel; Leah Dorazio (2015). *Advanced High School Statistics*. OpenIntro, Inc.

Wasserstein, Ronald L. & Nicole A. Lazar (2016). The ASA’s statement on *p*-values: Context, process, and purpose. *The American Statistician*, 70(2), 129-133.

Showcasing the Significance of Statistics to Students

A new school year is upon us, and with that comes new opportunities to engage students’ interest via distinctive and intriguing approaches. *This*IsStatistics, a public education initiative expanding awareness of the value of statistics, has several new, dynamic resources for teachers and students that showcase statistics as more than a class, but also a rewarding career. ***thisisstatistics.org***

THIS IS STATISTICS

Videos

The world of statistics is limitless, and our videos feature statisticians and data scientists who work on an impressive array of social and economic issues for high-profile companies, public-facing government agencies, and global nonprofit organizations.

News Feed

Looking for a unique way to connect statistics with another relevant subject? The *This*IsStatistics news blog includes posts and feature interviews with respected professionals about the immersion of statistics in data journalism, health care, and career development, among others. See *http://thisisstatistics.org/latest-news.*

Contest

Less than a month away from the presidential election, *This*IsStatistics has launched Prediction 2016, an election prediction contest for high-school and college undergraduate students. As they showcase their statistical savviness, students can also win cash and networking prizes. Learn more at *http://thisisstatistics.org/electionprediction2016*.

Webinar

Sports and statistics go hand-in-hand. Last month, the ASA and *This*IsStatistics hosted a sports statistics webinar featuring Dennis Lock, director of analytics with the Miami Dolphins; Stephanie Kovalchik, senior sport scientist with Tennis Australia; and Scott Evans, senior research scientist at Harvard University and member of the New England Symposium on Statistics in Sports. More than 100 high-school and undergraduate students participated to learn what it’s really like to use data off the court and field in making real-world decisions with big impact on professional sports. A recording of the webinar is now available at *http://thisisstatistics.org/sportsanalytics*.

Additional resources accompanying this lesson also are posted.

CONFIDENCE IN SALARIES IN PETROLEUM ENGINEERING

Susan A. Peters
University of Louisville
s.peters@louisville.edu

AnnaMarie Conner
University of Georgia
aconner@uga.edu

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Overview of Lesson
This lesson introduces students to bootstrapping methods for making inferences about a population parameter using a randomly selected sample from the population. Students use random samples of salaries for petroleum engineering graduates - —graduates employed in the profession earning the highest mean starting salary in 2014 - —and technology tools to calculate and interpret interval estimates for the mean population starting salary. They also explore the effects of sample size and confidence level on margin of error. Students draw conclusions using both the context of the activity and bootstrapping distributions generated from simulations. Students' explorations conclude with drawing inferences about a population proportion.

GAISE Components
This investigation follows the four components of statistical problem solving put forth in the *Guidelines for Assessment and Instruction in Statistics Education (GAISE) Report*. The four components are: formulate a question, design and implement a plan to collect data, analyze the data, and interpret results in the context of the original question.
This is a **GAISE Level C** activity.

Common Core State Standards for Mathematical Practice
2. Reason abstractly and quantitatively.
3. Construct viable arguments and critique the reasoning of others.
4. Model with mathematics.
5. Use appropriate tools strategically.

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Learning Objectives Alignment with Common Core and NCTM PSSM

Learning Objectives	Common Core State Standards	NCTM Principles and Standards for School Mathematics
Students will describe the effects of sampling variability for samples randomly selected from a population.	7.SP.A.2. Use data from a random sample to draw inferences about a population with an unknown characteristic of interest. Generate multiple samples (or simulated samples) of the same size to gauge the variation in estimates or predictions.	
Students will construct a bootstrapping distribution of means using a random sample.	S-IC.B.4. Use data from a sample survey to estimate a population mean or proportion; develop a margin of error through the use of simulation models for random sampling.	Develop and evaluate inferences and predictions that are based on data: • use simulations to explore the variability of sample statistics from a known population and to construct sampling distributions.
Students will use a bootstrapping distribution to find a margin of error for estimating a population mean or proportion.	S-IC.B.4. Use data from a sample survey to estimate a population mean or proportion; develop a margin of error through the use of simulation models for random sampling.	Develop and evaluate inferences and predictions that are based on data: • understand how sample statistics reflect the values of population parameters and use sampling distributions as the basis for informal inference.
Students will describe the effects of sample size and confidence level on margin of error.	S-IC.B.4. Use data from a sample survey to estimate a population mean or proportion; develop a margin of error through the use of simulation models for random sampling.	
Students will interpret the meaning of 95% confidence.		

Prerequisites
Students should know how to calculate and interpret numerical summary values for one variable data (mean, standard deviation, median, interquartile range) and know how to construct and interpret graphical displays of data including dot plots. Students should have some familiarity with data collection methods such as surveying and important constructs and concepts related to data collection including random sampling and representative samples. Students who have previously conducted simulations and encountered sampling distributions will benefit most from this lesson.

Time Required
This extensive two-part lesson will require about 100-150 minutes for each part, with Part 1 requiring two 50-minute class periods and Part 2 requiring two to three 50-minute class periods. One class period in each part should be devoted to formulating questions and data collection.

Materials and Preparation Required
- Pencil and paper
- One deck of cards per student group
- Bootstrapping software or Internet access (directions in this lesson will refer to a StatKey applet at http://lock5stat.com/statkey/)
- Calculator or statistics software for computing statistics and graphing data
- Data file
- Post-it notes to record class data
- Large number lines to display dotplots of class data

Confidence in Salaries in Petroleum Engineering
Teacher's Lesson Plan

Part 1: Informal Inference

Describe the Context and Formulate a Question

Ask students to speculate about professions they potentially should consider for the future and why. Have students articulate specific job characteristics that would be important to consider. Students may identify many characteristics, but focus on characteristics that students would want to know as part of determining whether the profession might be a good choice for the future. Ask students to state specific questions about these characteristics that could be answered with data.

After students have a chance to discuss various characteristics, inform them that one job that might be appealing is that of a petroleum engineer. According to a survey conducted by the National Association of Colleges and Employers (NACE), bachelor degree graduates from the class of 2014 who earned the highest average (mean) starting salary of $86,266 were those who majored in petroleum engineering. Focus students on salaries and job availability as two important characteristics for considering the viability of the major and graduates' likelihood of achieving this mean salary.

The series of activities that follows is based on answering the following question related to salary: What is the average starting salary for graduates majoring in petroleum engineering?

Collect Data

This lesson does not involve direct data collection. Instead, students will consider how data were collected by NACE to determine the average starting salary for 2014 petroleum engineering graduates. In particular, students will consider the activity questions for "Setting the Context."

Distribute the "Setting the Context" activity sheet, and ask students to work in pairs or in groups to answer items (1) and (2) on the activity sheet. These items are intended to focus students on the difference between a sample and a population and the importance of using random and representative samples to make inferences about a population. After students have a chance to answer the questions, discuss their responses. If students suggest that NACE should have worked with the population of all 2014 petroleum engineering graduates, ask students to generate reasons why collecting data from the population of all graduates, particularly data about salaries, may not be feasible or possible. As students discuss methods that NACE might have used to collect salary information from a sample of 2014 petroleum engineering graduates, ask students to justify why the resulting sample from using these methods is or is not likely to be representative of the population. Poll students about what methods they believe would yield representative samples.

An important aspect of any data collection method that should be mentioned is random selection. Although students might suggest different methods to increase representativeness such as stratifying graduates according to the type of institution from which they graduated, there still may be lurking variables that interfere with selecting a representative sample. Random selection is designed to control the effects of unidentified factors by ensuring equal probabilities for selecting units exhibiting these factors (or not).

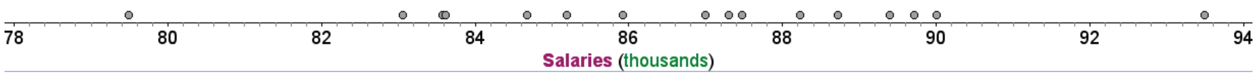
Ask students to consider NACE's actual data collection methods by first describing the methods to them. Some of the methods are specified on the activity sheet; other information can be obtained from the NACE (2015b) publication, *First destinations for the college class of 2014.* Ask students to consider whether the methods would produce a random and/or representative sample of 2014 graduates and why or why not (#3 from activity sheet). Positive aspects of the data collection methods include diversity in the institutions responding to the survey, the likelihood of truthful responses through anonymous reporting through institution contacts, and the presumably large size of the sample. Negative aspects of the data collection methods include an absence of randomization and a low response rate to the survey (190 institutions). Although the names of institutions providing data for the survey are provided by NACE in their report, the representativeness of these institutions in comparison with all undergraduate institutions granting degrees in petroleum engineering cannot be determined without extensive effort.

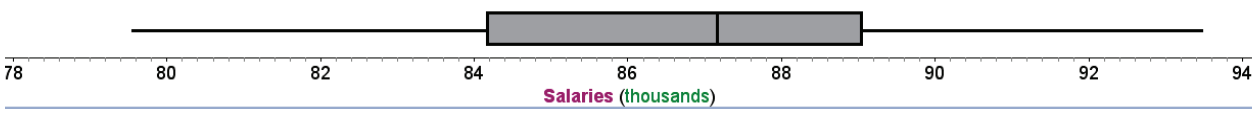
Lead ~~into~~ data analysis by asking students to focus on the meaning of an average salary of $86,266 if we were to assume that the NACE survey produced a representative sample (#4 from activity sheet) and what the average salary reveals about the larger set of data from which it was calculated. Focus on the fact that the data are likely to be variable but that the mean in and of itself tells nothing about the variability. Then, project the following quote, and ask students to comment on its meaning: "You can't fix by analysis what you bungled by design" (Light, Singer, & Willett, 1990, p. *v*.). Remind students that we perform analyses under the assumption that our sample data are representative of the larger population from which they are drawn. Randomization provides the best means for achieving samples representative of their respective populations.

Analyze Data

Ask students to work in pairs or in larger groups to respond to items (1) through (7) on the "Analyzing Data from a Single Sample" activity sheet. Students analyze salaries for a random sample of 16 petroleum engineering graduates and begin thinking about drawing inferences for the larger population of all starting salaries using this sample. The sample size of 16 was chosen specifically to align with the number of face cards used in the simulation, "Using Cards to Bootstrap." Make sure that students have a calculator or software to calculate summary values. Item (1) provides a good opportunity to review some basic statistics with students. If students are well versed in exploratory data analysis methods and with describing distributions, then little time needs to be devoted to this first item. Note the following summary values, dotplot, and boxplot for these data.

N	Mean	SE Mean	StDev	Minimum	Q1	Median	Q3	Maximum
16	86684.06	847.37	3389.46	79499.00	84152.50	87154.00	89605.50	93499.00





Interpret Results

These data are fairly symmetric, and although the sample size is relatively small, the symmetry and lack of outliers suggest that the mean and standard deviation are appropriate for describing the data. Use a Whip Around strategy to have groups share their descriptions from (1)—randomly select groups to share one observation about the distribution and continue in this manner until all ideas have been shared. As students present their responses, press them to not only report statistics but also to interpret the meaning of the measures. For example, the mean of approximately $86,684 means that if every one of the 16 engineers earned the same salary, they would each earn a salary of $86,684. This is not the case, however, as the approximate average deviation from the mean is $3,389. The middle 50% of salaries fall in the interval between $84,152.50 and $89,605.60. The person earning the least in this sample earns $79,499, which is $14,000 less than the person earning the maximum of $93,499.

As students continue to share their responses to items (2) through (7), focus students on the idea that sample characteristics rarely, if ever, are equivalent to the population characteristics whether the population is salaries from the NACE survey, salaries from some other population, or units different from salaries. Therefore, a sample mean is not likely to equal a population mean; however, without additional information about a population, a sample mean provides a reasonable estimate for the population mean. Introduce the idea of ***sampling variability***—that samples and their characteristics such as shape, measures of center, and measure of variation are likely to vary from sample to sample in repeated sampling—to suggest that this sample of size 16 could have been selected from the same population as the NACE sample. If students consider the variability in means to be too great for the sample of size 16 and the NACE sample to have been selected from the same population, ask students to speculate about what difference in means would suggest samples selected from the sample population. Point out that inference techniques present criteria for making these types of decisions.

Items (6) and (7) set up the idea of using samples to make inferences about populations. Point out to students that because we typically don't expect sample means to equal population means, we typically estimate a population characteristic using an interval of values—an ***interval estimate***. Inform students that they will explore one method for finding interval estimates: bootstrapping.

Part 2: Bootstrapping

Describe the Context and Formulate a Question

Before introducing bootstrapping to students, revisit the statistical question that was answered by the previous series of activities. In particular, ask students to identify the question, namely: What is the average starting salary for graduates majoring in petroleum engineering? Remind students that in the first series of activities, they answered the question using a single value. In the next series of activities, they will answer the question using an interval of values.

Ask students to again consider other questions they might wish to answer by using data about petroleum engineering graduates. Focus students on job availability as an important characteristic for considering the likelihood of graduates achieving this mean salary. In addition to constructing interval estimates for a population mean, students will construct interval estimates in response to the following question: What proportion of petroleum engineering graduates is unemployed?

Collect Data

This lesson does not involve direct data collection for the initial sample of 16 salaries. However, students will use sampling with replacement to select additional samples towards estimating the average starting salary for graduates majoring in petroleum engineering.

Return to the question from Part 1 that asked students to consider how close their estimate of the mean starting salary for all 2014 petroleum engineering graduates might be to the population mean. Ask students to assume that they only had their sample and the statistics they calculated from the sample to draw conjectures about an interval of values that would be reasonable for the population mean. Ask what information students considered when deciding upon this interval. Also ask students how confident they are that the population mean would be in this interval. Then ask students what additional information they might want to be more confident in constructing an interval to estimate the population mean. Depending upon their previous experiences, students might suggest obtaining a larger sample or additional samples. Point out to students that the only data they have available to them is the data from this single sample. Revisit the idea of representativeness to have students consider what the population might be if the sample truly were representative of the population. Lead into the idea of bootstrapping by asking students to consider how they might use this single sample to obtain additional samples.

Bootstrapping and Sampling with Replacement

Give students time to read the boxed information that appears on the "Bootstrapping and Sampling with Replacement" page and to respond to the question on the page. Engage students in a think-pair-share to think about, discuss, and share methods for sampling with replacement. Students may suggest strategies such as creating slips of paper for each salary and selecting slips (with replacement) from a hat. If students previously worked with random number tables, they may suggest assigning numbers to each possible outcome and using a random number table to simulate sampling with replacement. For each strategy presented, ask students to be explicit in describing how each of the 16 salaries is represented, how the process incorporates randomization (so that each of the 16 salaries has the same probability of being selected), and how the process incorporates the idea of replacement so that each of the 16 values can be selected for each of the 16 selections.

Note that the bootstrapping process and using sample data as if it were population data may not be intuitive for students. Remind students that ideally we would work with the population directly; because we realistically can only work from the sample, we try to approximate characteristics of the population as closely as possible by using sample data. In this way, students can consider the population to be many copies of the sample. Rather than making copies of the sample, we use sampling with replacement to repeatedly select samples from our sample. In the case of salaries for 2014 petroleum engineering graduates, we assume that each starting salary from the sample represents many similar starting salaries from the population of all petroleum engineering graduates.

From this point forward, we refer to the 16 salaries as a sample of salaries. Our use of this terminology is an abbreviated way of saying that the salaries were reported by a sample of 2014 petroleum engineering graduates from the population of all 2014 petroleum engineering graduates. The sampling unit is the graduate, but the observational unit is the salary. Students may pick up on this slight change in wording.

Using Cards to Bootstrap

Students use a deck of cards to simulate sampling with replacement from the given sample of 16 salaries [items (1) through (5) for "Using Cards to Bootstrap"]. Research suggests that performing simulations by hand before using technology can aid students in understanding the conceptual ideas that underlie statistical inference (Pfannkuch, Forbes, Harraway, Budgett, & Wild, 2013). Students will combine their results with those from the rest of the class to conjecture appropriate interval estimates for the population mean starting salary [items (6) through (10) for "Using Cards to Bootstrap"]. Prior to beginning this activity, display a large number line such as the number line displayed in item (6) in the classroom. Students should record their sample means on post-it notes and position the post-it notes as dots above the number line to create a dotplot of simulation results from the class.

As part of the simulation process, students compare one or more simulated bootstrap sample salaries with the original sample salaries to reinforce the notion of sampling variability [item (2)]. While they are working, encourage students to consider the shape, center, and variation of the bootstrap samples in comparison with the original sample. Students should observe differences in these characteristics, but ask them to focus on the variability in the samples in comparison with the variability in characteristics. Students create dotplots from the bootstrap sample means to begin creating a bootstrap distribution; asking students to compare the variability of the samples with the variability of the bootstrap distribution can help students to see the reduced variation in a distribution of means.

After students complete the activity, focus discussion on items (8) and (9). If students do not express greater confidence for suggesting an interval estimate from the class display, question students about how the size of a sample affects their confidence for describing distribution characteristics. Just as larger samples instill greater confidence for drawing inferences about populations, larger distributions of statistics instill greater confidence for drawing inferences about parameters. The distribution of bootstrap sample means from (6) is a distribution of a sample of sample means. Students should have greater confidence in estimating an interval estimate for the population mean from the dotplot displaying sample means from the class, which should then motivate additional simulation.

Analyze Data

Bootstrapping for Confidence
Students will need Internet access and computing technology in the form of a laptop or tablet to access the StatKey applets (http://lock5stat.com/statkey) to create a bootstrap distribution for 1000 sample means. Students should work with a partner on items (1) through (5) from "Bootstrapping for Confidence" and use the applet to find a 95% confidence interval for the population mean starting salary of petroleum engineering graduates.

When all students have recorded 95% confidence intervals for the population mean salary, ask students to share their intervals with the class. Then ask students to respond to the following questions.

1. How many of the class intervals capture the mean of $86,266 reported by NACE?

2. Would these intervals suggest that $86,266 could be the population mean? Why or why not?
3. How are the class intervals similar?
4. How do the class intervals differ?

These questions are intended to lead students into considering the meaning of 95% confidence. Most, if not all, of the class intervals will capture the mean reported by NACE to suggest that the population mean could be $86,266. The intervals likely will have different centers (and endpoints) but similar widths. The center of each interval likely will be close to the mean of the original sample, $86,684. A common misinterpretation of confidence intervals stems from a desire to interpret 95% as the percentage of sample data captured in the interval (West & Ogden, 1998). Focus students on the original sample used to conduct the simulation to generate a confidence interval, and ask students whether they see any relationship between the data and the interval. In particular, ask students to compare individual salaries with the confidence interval. The important point to emphasize is that the confidence interval tells us nothing about individual data values—the interval only provides an estimate for a population parameter, which in this case is a mean. Analysis of these intervals reveals that in the long run, approximately 95% of the intervals capture the population mean. Associating 95% with multiple intervals can prevent students from falling into common traps for interpreting confidence intervals. Students should focus on 95% as the percentage of intervals that capture the parameter and associate this percentage with level of confidence. Because confidence intervals are constructed from a sample, students tend to want to interpret the intervals in terms of a sample characteristic rather than the population parameter for which the interval is intended to provide an interval of plausible estimate values (West & Ogden, 1998).

Gaining or Losing Confidence

Students next explore the effects of confidence level on the width of confidence intervals by responding to items (1) through (5) on "Gaining or Losing Confidence." Although not necessary for meeting the standards addressed by this lesson, students' understanding of confidence can be enhanced by focusing on the intervals and repeatedly considering the intervals to be estimates for the population mean. Focus discussion on item (4). The larger number of population estimates resulting from a wider interval of estimated values should translate into more confidence for capturing the population mean, a notion that tends to be counterintuitive for students.

Considering the Effects of Sample Size

Students also should consider the effects of sample size on the width of confidence intervals. Students will work with samples of size 64 and 256, which were chosen to better enable students to discover the inverse square root relationship between sample size and margin of error. Students should work in pairs to develop responses for items (1) through (7) on "Considering the Effects of Sample Size". Time can be saved by providing students with a file that contains the data for 64 starting salaries so that students can copy and paste the data into the applet without needing to key in all 64 values. Create a text file containing a heading of "Salary" and each of the 64 salaries on separate lines. Provide students with the file, and make sure that they know the name of the file.

Note the following summary values for this sample. If students need additional time describing distributions, spend time graphing these data and describing the distribution, paying particular attention to shape, center, and variation.

N	Mean	SE Mean	StDev	Minimum	Q1	Median	Q3	Maximum
64	85784.56	466.23	3729.80	75773.00	83443.00	85446.50	88397.00	95127.00

After students respond to item (7), focus discussion on items (2), (5), and (7). For (2), pay particular attention to students' interpretation of the 95% confidence interval to potentially address common pitfalls such as claims that the confidence interval provides a 95% probability for capturing the population mean. A single interval is not associated with probability for capturing the mean—the interval either does or does not capture the population mean. In the long run, 95% of confidence intervals constructed in a similar manner would capture the population mean; 95% confidence does not tell us anything about whether a single confidence interval captures the population parameter but rather refers to the long-term behavior of the process.

For (5), focus on similarities such as the interval centers being close in value to the sample mean. Also focus on differences such as the widths of the intervals. The width of the interval for the sample of size 64 is smaller than the width of the interval for the sample of size 16. Focus on intervals and their widths leads naturally into discussing margin of error (7), which is also known as the half-width of the interval.

Students should further consider the effects of sample size on the margin of error by responding to items (8) through (12). When discussing these items, focus on the inverse square root relationship to suggest that halving the margin of error would occur again if we took a random sample of 256 starting salaries. Also reinforce the relationship between the sample mean and the mean of the bootstrap distribution, proper interpretation of the 95% confidence interval, the relationship between the population mean and the confidence interval, and how sample size affects the margin of error.

Interpret Results

Bootstrapping for Confidence in Employment

Throughout students' analyses, students interpreted results in the context of the data with guidance from the instructor. To consider using bootstrapping procedures to estimate population proportions, ask students to work independently on items (1) through (5) of "Bootstrapping for Confidence in Employment." Students find confidence intervals for a population proportion using StatKey and interpret the intervals within the context of the data. Before starting, students may need some help connecting the bootstrapping process for estimating a population mean with the bootstrapping process for estimating a population proportion. Students may need to consider a much smaller sample and resample by hand from that smaller sample before using StatKey to simulate resampling from the larger sample.

Students should work in groups of four to interpret the confidence interval in terms of an interval estimate for the population proportion of petroleum engineering graduates currently seeking employment. They also consider ways in which they could find more precise estimates for the population proportion.

Students should share their results in groups in such a way as to highlight the variations in their results. Each student is assigned a number between one and four. All students assigned number one meet to discuss their group's responses to items (1) through (5). Similarly, students form groups from those assigned numbers two, three, and four to discuss results. Inform students that they should come to agreement on their responses to (3), (4) and (5) and be prepared to share their responses or questions they have about these items with the rest of the class. As groups discuss their results, circulate among the groups to ensure proper interpretations of intervals. After groups have a chance to discuss their results and come to consensus, ask students to return to their original groups to discuss any potential differences that arose from meeting with members of other groups. Bring the class back together as a whole, and discuss items (1) through (5) as needed.

Now that students have analyzed considerable data, return to the NACE survey and the data collection methods used by NACE. Tell students that the data they explored essentially were random samples from the NACE survey data. Ask students: do you believe that the average starting salary for petroleum engineers and the proportion of petroleum engineering majors currently seeking employment put forth by NACE generalizes to *all* 2014 petroleum engineering graduates? Why or why not? If students do not believe that results from NACE data generalize to the larger population, ask students for implications from their analyses.

Suggested Assessment

Ask students to complete items (1) and (2) from "Try This on your Own." Students should provide complete interpretations of the processes used to find the confidence interval, the confidence interval, and the margin error in their explanations.

Possible Differentiation

The lesson in general is targeted for students at GAISE Level C; however, lesson activities associated with the Part 1 could be implemented with students at Level B. These students may need some additional guidance for representing and describing sample data when "Analyzing Data from a Single Sample" such as being told which representations and statistics to use.

Students at Level B may need greater differentiation for activities associated with Part 2. Specifically, they may need to discuss the concepts introduced in "Bootstrapping and Sampling with Replacement" in conjunction with completing the first step of "Using Cards to Bootstrap." After using cards to sample with replacement, students may be able to consider additional processes that could be used to sample with replacement. Similarly, after completing the second step of "Using Cards to Bootstrap," students may observe that different samples yield different population estimates to suggest why using an interval estimate might be better than using point estimates for a population characteristic. Students at Level B also will need to spend some time comparing the sample distribution with the distribution of means that emerges in "Using Cards to Bootstrap." Similarly, they should make multiple comparisons between the sample distribution and the distribution of means in "Bootstrapping for Confidence." Rather than immediately generating 1000 samples using the software, students should generate many samples and examine the emerging distribution of means to compare characteristics of the sample distribution with characteristics of the distribution of sample means. Students at Level B might skip "Gaining or Losing Confidence" and work more slowly through parts (1) through (5) of "Considering the Effects of Sample Size" by again comparing the sample distribution with the emerging distribution of sample means. Differentiation needed for "Bootstrapping for Confidence in employment" and "Try this on your Own" similarly should focus more on making the situation as concrete as possible and slowly generating the distribution of statistics and thus focus more on the beginning steps of the activities than on the later steps.

Possible Extension

Statistics educators argue that statistical activities should involve use of real data. Others go further in suggesting that activities "should use real data that matters" (Tintle et al., 2016), data that can be used to make decisions. Although students may not make decisions about their future career by examining statistics related to petroleum engineering, they can use the strategies and techniques presented in the context of petroleum engineering graduates to make decisions about their futures. One extension that can benefit students would be to have students conduct research for an occupation of interest to them. Although NACE does not provide free access to their data on recent college graduates, salary and unemployment data are freely available from the Bureau of Labor Statistics through their Current Population Survey (http://www.bls.gov/cps/data.htm). Students can use data and statistics reported by the Bureau of Labor Statistics for occupations of interest to find interval estimates for parameters.

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ANNOUNCEMENTS

Christine Franklin Begins Role as ASA K-12 Statistical Ambassador

Christine Franklin (the lead author of the GAISE Pre-K–12 Report (*www.amstat.org/education/gaise*) and the new SET Report (*www.amstat.org/asa/files/pdfs/EDU-SET.pdf*) , has started her role as the inaugural ASA K-12 Statistical Ambassador. Chris will provide leadership in the creation and presentation of professional development materials for teacher educators and teachers. She will present at national conferences, conduct workshops, collaborate with ASA Chapters to enhance their education initiatives, and assist in outreach to the STEM education community. For more information, please see *http://magazine.amstat.org/blog/2016/04/01/k12ambassador16* or contact Chris at *christine@amstat.org*.

ASA 2016 Poster and Project Winners Announced

The ASA is pleased to announce the winners of the 2015 poster and project competitions at *http://magazine.amstat.org/blog/2016/08/01/posterwinners-aug16* . The competitions offer opportunities for students to formulate questions and collect, analyze and draw conclusions from data. Winners were recognized with plaques, cash prizes, certificates and calculators, and their names were published in Amstat News. To view the winning posters and projects or for more information, visit *www.amstat.org/asa/education/ASA-Statistics-Poster-Competition-for-Grades-K-12.aspx* and *http://www.amstat.org/asa/education/ASA-Statistics-Project-Competition-for-Grades-7-12.aspx.*

2017 Poster and Project Competitions

Introduce your K–12 students to statistics through the annual poster and project competitions directed by the ASA/NCTM Joint Committee on the Curriculum in Statistics and Probability. The competitions offer opportunities for students to formulate questions and collect, analyze and draw conclusions from data. Winners will be recognized with plaques, cash prizes, certificates and calculators, and their names will be published in Amstat News. Posters (grades K-12) are due every year on April 1. Projects (grades 7-12) are due on June 1. For more information, visit *www.amstat.org/asa/education/ASA-Statistics-Poster-Competition-for-Grades-K-12.aspx* and *www.amstat.org/asa/education/ASA-Statistics-Project-Competition-for-Grades-7-12.aspx*.

Statistics Education Web (STEW) Lesson Plans

If you have not been to the redesigned STEW website to see the collection of lesson plans, check it out! We are currently seeking new lesson plans, especially for grades K-5, and 6-8. See site for details at *www.amstat.org/ASA/Education/STEW/home.aspx* .

Statistics in Schools Program of U.S. Census Bureau

Statistics in Schools is a free program from the U.S. Census Bureau offering data, tools, and activities that correspond with relevant education standards and guidelines and that use real-life census information for teachers to incorporate into their lesson plans. Through this program, students can connect the world around them to what they are learning in the classroom. Use of Statistics in Schools in lesson plans helps students gain important skills, such as understanding statistics and analyzing data, in a variety of subjects — including history, geography, sociology, and math—at multiple grade levels. To learn more, visit *www.census.gov/schools*.

Free ASA Webinar on Reproducible Research on November 16, 2016

The ASA is sponsoring a free webinar entitled “Teaching Reproducible Research: Inspiring New Researchers to Do More Robust and Reliable Science” featuring Karl Broman (University of Wisconsin) and Mine Çetinkaya-Rundel (Duke University) and moderated by Benjamin Baumer (Smith College). The webinar is Wednesday, November 16, 2016, 2:30–3:30 p.m. EST, and there is no fee to attend but you must register. For more information and to register, visit: *www.amstat.org/ASA/Education/Web-Based-Lectures.aspx*.

Free Statistics Education Webinars

The ASA offers free webinars on K–12 statistics education topics at *www.amstat.org/asa/education/K-12-Statistics-Education-Webinars.aspx.* Newly posted webinars include Teaching Simulation-Based Inference by Kari Lock Morgan and Smelling Parkinson’s Disease and Other Simulation-Based Inference Activities by Doug Tyson. This series was developed as part of the follow-up activities for the Meeting Within a Meeting Statistics Workshop (*www.amstat.org/asa/education/MWM/home.aspx*) . The Consortium for the Advancement of Undergraduate Statistics Education also offers free webinars on undergraduate statistics education topics at *www.causeweb.org*. The ASA/American Mathematical Association of Two-Year Colleges (AMATYC) Joint Committee also offers free statistics webinars through AMATYC at *www.amatyc.org/?page=Webinars*.

Free ASA Sports Statistics Webinar

The ASA and its public education campaign, *This*IsStatistics (*www.thisisstatistics.org*), conducted a sports statistics webinar featuring Dennis Lock, director of analytics with the Miami Dolphins; Stephanie Kovalchik, senior sport scientist with Tennis Australia; and Scott Evans, senior research scientist at Harvard University and member of the New England Symposium on Statistics in Sports. For more insight on careers in sports statistics, access a recording of the ASA’s sports statistics webinar at *http://thisisstatistics.org/sportsanalytics*.

Statistical Education of Teachers (SET) Report

www.amstat.org/asa/files/pdfs/EDU-SET.pdf

The American Statistical Association (ASA) has issued the Statistical Education of Teachers (SET) Report, which calls on mathematicians, statisticians, mathematics educators and statistics educators to collaborate in preparing pre-K–12 teachers to teach intellectually demanding statistics courses in their classrooms. SET was commissioned to clarify the recommendations for teacher statistical preparation in the Conference Board of the Mathematical Sciences' Mathematical Education of Teachers II report. The SET report uses the ASA Pre-K–12 GAISE Framework as the structure for outlining the content and conceptual understanding teachers need to know in assisting their students develop statistical reasoning skills. The report facilitates the understanding of key topics such as what sets statistics apart as a discipline distinct from mathematics, the difference between statistical and mathematical reasoning, and the role of probability in statistical reasoning. SET is intended for everyone involved in the statistical education of teachers, both the initial preparation of prospective teachers and the professional development of practicing teachers.

GAISE 2016 College Report

The ASA board of directors endorsed the updated 2016 Guidelines for Assessment and Instruction in Statistics Education (GAISE) College Report, which provides an update of the recommendations for teaching introductory statistics. The updated GAISE College Report and the GAISE Pre-K–12 Report are available online at *www.amstat.org/education/gaise*.

ASA Stats 101 Toolkit

Many teachers of introductory statistics courses, whether at the high school, 2 year or 4 year college or university level are trained in mathematics and may not have training or experience with statistics. At the request of the 2015 President of the American Statistical Association, David Morganstein, a group of statistical educators led by Dick De Veaux has written a series of case studies, designed to show statistics in action, rather than showing it as a branch of mathematics. Each case starts with a real world problem and leads the reader through the steps taken to explore the problem, highlighting the techniques used in introductory or AP statistics classes. Sometimes the analysis goes slightly past the methods taught in such an intro course, but the analysis is meant to build on simpler techniques and to provide examples of real analyses, typical of the kind of analysis a professional statistician might perform. Our hope is that these case studies can both provide context and motivation for the instructor so that the methods in the intro course come alive, rather than seem a list of cookbook formulas. They can be used as examples in class, or just as guides for what a statistical analysis might entail. This repository can be found at *community.amstat.org/stats101/home*.

Episode 21 of STATS+STORIES Available

Episode 21 of Stats+Stories, a "Winning Formula for Sports," is now available. Dennis Lock (@LockAnalytics) currently serves as Director of Analyticsfor theMiami Dolphins NFL team. In his role, he supports football operations through research and statistical analyses. He has been a consultant for the Iowa State University men's basketball team and is a co-author of a popular statistics textbook. He joined the Stats+Stories regulars to discuss the importance and influence of statistical insights for sports. To listen now, please visit *www.statsandstories.net* or iTunes.

Significance Opens Archives

Significance magazine has opened its 10-year archives for access by the public. The magazine's volumes 1 through 10 are available to read, free of charge, at *www.statslife.org.uk/significance/back-issues*. Further, all magazine content will be made freely available one year after its initial publication. Editor Brian Tarran believes open access will demonstrate the importance of statistics and the contributions it makes in all areas of life. Royal Statistical Society and ASA members and subscribers will continue to enjoy exclusive access to the latest magazine content.

Data-Driven Mathematics Modules Available Free Online

Data-Driven Mathematics is a series of modules funded by the National Science Foundation and written by statisticians and mathematics teachers. Intended to complement a modern mathematics curriculum in the secondary schools, the modules offer materials that integrate data analysis with topics typically taught in high-school mathematics courses and provide realistic, real-world data situations for developing mathematical knowledge. The copyrights have been transferred from the original publisher to ASA. Scanned copies of these books are freely available to download at *www.amstat.org/asa/education/K-12-Educators.aspx*.

Stats.org Resources

Stats.org is a collaboration between the ASA and Sense About Science USA that aims to provide guidance regarding statistical literacy to journalists and the public. It provides interesting examples and stories that can be used in the classroom.

Census at School Program Reaches More Than 50,000 Students

The ASA's U.S. Census at School program (*www.amstat.org/censusatschool*) is a free, international classroom project that engages students in grades 4–12 in statistical problem solving. The students complete an online survey, analyze their class census results, and compare their class with random samples of students in the United States and other participating countries. The project began in the United Kingdom in 2000 and now includes Australia, Canada, New Zealand, South Africa, Ireland, South Korea and Japan. The ASA is seeking champions to further expand the U.S. Census at School program nationally. For more information about how you can get involved, see the article online at *http://magazine.amstat.org/blog/2012/02/01/censusatschool-2/* or email Rebecca Nichols at *rebecca@amstat.org*.

ANNOUNCEMENTS

Explore Census at School Data with TuvaLabs

TuvaLabs provides free, real data sets, lessons, and visualization tools to enable teachers to teach statistics and quantitative reasoning in the context of real-world issues and topics. The ASA has provided TuvaLabs with a clean Census at School data set with 500 cases and 20 attributes that is now freely available in TuvaLabs for students and teachers to explore online with their visualization tool and Census at School–adapted lesson plans. Start exploring Census at School data with TuvaLabs at *https://tuvalabs.com/datasets/census_at_school__clean_data/#/* . Other TuvaLabs data sets and lessons are available at *www.tuvalabs.com*.

Online Community for ASA K-12 Teacher Members

An online community for ASA K-12 Teacher Members will allow participation in online discussions and sharing resources with other members. More information is available at *http://community.amstat.org*. Not yet an ASA K-12 Teacher Member, you can start your free one-year trial online at *ww2.amstat.org/membership/k12teachers*.

World of Statistics Website and Resources

The free international statistics education resources created during the 2013 International Year of Statistics are now available and ongoing through the new World of Statistics website. Teachers everywhere can access in a wealth of statistics instruction tools and resources from around the world at *www.worldofstatistics.org*.

PROJECT-SET

Project-SET is an NSF-funded project to develop curricular materials that enhance the ability of high-school teachers to foster students' statistical learning regarding sampling variability and regression. All materials are geared toward helping high-school teachers implement the Common Core State Standards for statistics and are closely aligned with the learning goals outlined in the Guidelines for Assessment and Instruction in Statistics Education: A Pre-K–12 Curriculum Framework (GAISE) report. For more information, visit *http://project-set.com*.

LOCUS Assessment Resources

LOCUS (*http://locus.statisticseducation.org*) is an NSF Funded project focused on developing assessments of statistical understanding across levels of development as identified in the Guidelines for Assessment and Instruction in Statistics Education (GAISE). The intent of these assessments is to provide teachers, educational leaders, assessment specialists, and researchers with a valid and reliable assessment of conceptual understanding in statistics consistent with the Common Core State Standards (CCSS). The LOCUS Website offers online assessment tools to measure statistical understanding. Create an account and manage test requests to receive immediate results from these automatically scored assessments. This is a great way for students to practice taking assessments online. Additional Professional Development resources are available with questions that are accompanied by high-quality commentaries written alongside student samples.

YouTube Videos on Descriptive Statistical Concepts

https://www.youtube.com/user/profdstangl/playlists

Need assistance in teaching your students statistical thinking? Through funding from Duke University and the American Statistical Association, Dalene Stangl, Kate Allman, Mine Cetinkaya-Rundel, and a group of Duke students have created a set of 52 videos to help you understand and teach basic descriptive statistical concepts. The videos are organized into five units. Within each unit there are videos covering core concepts, pedagogy, JMP software, and applet demonstrations. Unit one covers data and explains the structure of the videos. Unit two covers one variable descriptive statistics, transforming a variable, and the normal curve. Unit three covers description of relationships between two categorical variables (contingency tables) and between one categorical and one numeric (side-by-side boxplots). Unit four covers description of relationship between two numeric variables using correlation and regression. Unit five pulls all the concepts together in review videos. We hope you find them useful. Enjoy!

Videos from Data to Insight Accessible Free on YouTube

Chris Wild's "Data to Insight: An Introduction to Data Analysis" is a free, online, hands-on introduction to statistical data analysis. The videos which make up most of its "teaching content" have been made conveniently accessible on YouTube. While "Data to Insight" prototypes a next-generation introductory statistics course, many of its videos are immediately useful for current high school and lower level university statistics courses. The videos are indexed at *www.stat.auckland.ac.nz/~wild/d2i/4StatEducators* together with an outline of their content and the course-design philosophy (see also the YouTube channel "Wild About Statistics").

But for those actually want to learn about statistics, "materials" is only one part of the story. As we know from your own teaching, what learners do (activities) is more important than what they simply see. The course itself starts formally on October 3 and runs for 8 weeks. However, it is self-paced and can be joined at any time till mid-December at *www.futurelearn.com/courses/data-to-insight*.

Against All Odds: Inside Statistics

www.learner.org/courses/againstallodds/index.html

Against All Odds is a free video series teaching introductory statistics concepts in context of real-life applications. This is an updated video series developed by Annenberg Learner (the producers of the original version in the 1980's) and contains videos, a glossary, teacher guides and student guides.

ANNOUNCEMENTS

Mobilize: Engaging Secondary Schools in Data Science

Robert Gould, Lead Principal Investigator

Statistics teachers know that requiring students to collect data is an effective way of engaging them in data analysis. Mobilize is an NSF-funded project that has developed a technology suite that allows students to engage in Participatory Sensing campaigns. In a PS campaign, students use their mobile devices to create a community that not only gathers data, but shares both the data and the analysis. The software includes an interactive "dashboard" that allows students to explore multivariate relations among variables that are numerical, categorical, location, data-and-time, text, and image.

The suite is used in a Mobilize-developed curriculum, the year-long course Introduction to Data Science (IDS). IDS is a "C" approved mathematics course in the University of California A-G requirements, which means that successful completion of IDS validates Algebra II and provides an alternative admissions pathway to the University of California and California State University systems. To date, IDS has been taught in over 35 classes and is still expanding.

The Mobilize project is a partnership between UCLA's Department of Statistics and Graduate School of Education and Information Studies, and the Los Angeles Unified School District, the nation's second-largest school district. Mobilize is interested in identifying additional schools or districts that might be interested in adopting the IDS course or using the Mobilize technology suite. To learn more, please contact LeeAnn Trusela, Mobilize Project Director, at *support@mobilizingcs.org* or visit the Mobilize website at *www.mobilizingcs.org*

Albert Einstein Distinguished Educator Fellowship Program

Albert Einstein Distinguished Educator Fellowship Program is now accepting applications for 2017-2018 fellowship year. Applications are due November 17, 2016.

The AEF Program provides a unique opportunity for accomplished K-12 educators in the fields of science, technology, engineering, and mathematics (STEM) to serve in the national education arena. Fellows spend 11 months working in a Federal agency or U.S. Congressional office, bringing their extensive classroom knowledge and experience to STEM education program and/or education policy efforts. Program applications are due November 17, 2016, and must be submitted through an online application system. Information about the Albert Einstein Distinguished Educator Fellowship Program, including eligibility requirements, program benefits, application requirements, and access to the online application system can be found at *http://science.energy.gov/wdts/einstein*.

UPCOMING CONFERENCES

National Council of Teachers of Mathematics (NCTM) Annual Meeting & Exposition

More Info: *www.nctm.org/Conferences-and-Professional-Development/Annual-Meeting-and-Exposition*

When: April 5–8, 2017

Location: San Antonio, Texas

Stop by the ASA booth in the exhibit hall for materials and resources

U.S. Conference on Teaching Statistics (USCOTS)

More Info: *www.causeweb.org/cause/uscots/uscots17*

When: May 18 - 20, 2017, The Penn Stater Conference Center Hotel, State College, Pennsylvania

BALTIMORE JSM2017

Joint Statistical Meetings (JSM)

More Info: *www.amstat.org/jsm*

When: July 29 - August 3, 2017

Location: Baltimore, Maryland

The Meeting Within a Meeting Statistics Workshop for Math and Science Teachers

More Info: *www.amstat.org/asa/education/MWM/home.aspx*

When: August 1-2, 2017

Location: Baltimore, Maryland (JSM 2017)

Beyond AP Statistics (BAPS) Workshop

More Info: *www.amstat.org/asa/education/MWM/home.aspx*

When: August 2, 2017

Location: Baltimore, Maryland (JSM 2017)

PREDICTION ★ 2016

Predict the Next U.S. PRESIDENT Using Statistics

Photos by Gage Skidmore

The American Statistical Association is calling on college undergraduate and high school students to compete in a contest to predict the next commander in chief using statistics, the most rigorous scientific method for prediction known.

Winners Will Receive

- Exposure to the nation's top statisticians and data scientists
- Bragging rights among politicos and pundits
- Complementary American Statistical Association membership
- Election Prediction 2016 T-Shirt
- $200 in cash

Submit by October 30, 2016

For contest details, visit
ThisIsStatistics.org/ElectionPrediction2016

THIS IS STATISTICS

Brought to you by ASA

Learn more about careers in statistics at **ThisIsStatistics.org**

@ThisIsStats

Sponsored by the American Statistical Association (ASA)

THIS IS STATISTICS

HELP US RECRUIT THE NEXT GENERATION OF STATISTICIANS

The field of statistics is growing fast. Jobs are plentiful, opportunities are exciting, and salaries are high. So what's keeping more kids from entering the field?

Many just don't know about statistics. But the ASA is working to change that, and here's how you can help:

- Send your students to ***www.ThisIsStatistics.org*** and use its resources in your classroom. It's all about the profession of statistics.
- Download a handout for your students about careers in statistics at ***www.ThisIsStatistics.org/educators***.

If you're on social media, connect with us at ***www.Facebook.com/ThisIsStats*** and ***www.Twitter.com/ThisIsStats***. Encourage your students to connect with us, as well.

The site features include:

- Videos of young statisticians passionate about their work
- A myth-busting quiz about statistics
- Photos of cool careers in statistics, like a NASA biostatistician and a wildlife statistician
- Colorful graphics displaying salary and job growth data
- A blog about jobs in statistics and data science
- An interactive map of places that employ statisticians in the U.S.

STatistics Education Web

STEW

Lesson Plans Available on Statistics Education Web for K–12 Teachers

Statistics Education Web (STEW) is an online resource for peer-reviewed lesson plans for K–12 teachers. The lesson plans identify both the statistical concepts being developed and the age range appropriate for their use. The statistical concepts follow the recommendations of the *Guidelines for Assessment and Instruction in Statistics Education (GAISE) Report: A Pre-K-12 Curriculum Framework*, *Common Core State Standards for Mathematics*, and *NCTM Principles and Standards for School Mathematics*. The website resource is organized around the four elements in the GAISE framework: formulate a statistical question, design and implement a plan to collect data, analyze the data by measures and graphs, and interpret the data in the context of the original question. Teachers can navigate the site by grade level and statistical topic. Lessons follow Common Core standards, GAISE recommendations, and NCTM Principles and Standards for School Mathematics.

Lesson Plans Wanted for Statistics Education Web

The editor of STEW is accepting submissions of lesson plans for an online bank of peer-reviewed lesson plans for K–12 teachers of mathematics and science. Lessons showcase the use of statistical methods and ideas in science and mathematics based on the framework and levels in the *Guidelines for Assessment and Instruction in Statistics Education (GAISE)* and *Common Core State Standards*. Consider submitting several of your favorite lesson plans according to the STEW template to *steweditor@amstat.org*.

For more information, visit *www.amstat.org/education/stew*.

CENSUS at SCHOOL

FREE international classroom project to engage students in statistical problem solving

Teach statistical concepts, statistical problem solving, measurement, graphing, and data analysis using your students' own data and data from their peers in the United States and other countries.

Complete a brief online survey (classroom census)

13 questions common to international students, plus additional U.S. questions

15–20-minute computer session

Analyze your class results

Use teacher password to gain immediate access to class data.

Formulate questions of interest that can be answered with Census at School data.

Collect/select appropriate data

Analyze the data—including appropriate graphs and numerical summaries for the corresponding variables of interest

Interpret the results and make appropriate conclusions in context relating to the original questions.

Compare your class census with samples from the United States and other countries

Download a random sample of Census at School data from United States students.

Download a random sample of Census at School data from international students (Australia, Canada, New Zealand, South Africa, and the United Kingdom).

International lesson plans are available, along with instructional webinars and other free resources.

www.amstat.org/censusatschool

For more information about how you can get involved,
email Rebecca Nichols at *rebecca@amstat.org*.

Bridging the Gap

Between Common Core State Standards and Teaching Statistics

Twenty data analysis and probability investigations for K–8 classrooms based on the four-step statistical process as defined by the Guidelines for Assessment and Instruction in Statistics Education (GAISE)

www.amstat.org/education/btg

MAKING SENSE OF STATISTICAL STUDIES

Making Sense of Statistical Studies consists of student and teacher modules containing 15 hands-on investigations that provide students with valuable experience in designing and analyzing statistical studies. It is written for an upper middle-school or high-school audience having some background in exploratory data analysis and basic probability.

www.amstat.org/education/msss