Engaging Activities to Introduce Key Ideas in AP Statistics

NCTM 2013 Annual Meeting and Exposition

Descriptive Statistics

Perceptions on Height

Purpose: As a class, students construct four distributions of the students' perception of the average (mean) height of the class. The distributions provide a reference for a discussion on distributions shape, center, and spread. This is a great first day of class activity.

Description: Each student receives four small (1" x 1.5") Post-it® notes: yellow, purple, blue, and pink. On the yellow Post-it, students write and (A) and (B) on it (the A directly above the B). Next to the (A), students must write their height in inches. You should discourage student conversation throughout the activity until the discussion period. Ask students to place their pencil on the Post-it next to the (B), close their eyes, and then write what they believe to be the class' average height inches (whole numbers only). When they are all done, have two students collect the yellow Post-its. Next, students must look around the room, and then write what they believe to the class' average height on the blue Post-it. Encourage them to change their minds if they believe their last guess to be inaccurate. When they are all done, have two students collect the blue Post-its. Next, students must stand up, look around the room, and then write what they believe to the class' average height on the purple Post-it. Encourage them to think about their own height and to change their minds if they believe their last guess to be inaccurate. When they are all done, have two students collect the purple Post-its. Finally, tell students to pick up their pink Post-it and pen, and then <u>silently</u> line up in a continuum from shortest to tallest in 30 seconds. After they are all lined up, tell them to write what they believe to the class' average height on the pink Post-it. Encourage them to think about their own height and to change their minds if they believe their last guess to be inaccurate. Meanwhile, the teacher should draw four axes labeled "height" on the board, and labeled for each Post-it color. When students are all done writing their estimates, have them go to the board and place their pink Post-it on the Pink axis. Tell them to stack Post-its that have the same height (creating a dot plot). After students have placed all the pink Post-its, they should place the purple, then the blue, then the yellow Post-its. The teacher may discuss the shape, center and spread of each distribution after each is placed on the board, or after all have been place on the board. The discussion should include how increasing information available to students changes the center and spread of the distribution.

Note: Good "Day 1" Activity

Presenters: Scott Galson (sdgalson@cps.edu) and McKendry Marano (mkmarano@cps.edu)

Making the Data

Purpose: Students develop their own data lists that meet criteria based on mean, median, mode, IQR, standard deviation, and range.

Description: There are many different tasks for students to do. Some examples:

1. Give two sets of data with the same mean, but different standard deviations.
2. Give two sets of data with the same standard deviation, but different means.
3. Create a set of data (n=10) that is symmetric, but not normal.
4. Create a set of data (n=10) that the mean = median, but not symmetric.

Least Squares Regression

Three Data Sets – Same LSRL and r^2 *(Handout)*

Purpose: Students develop least squares regression models for three data sets and assess which model best fits the data set. This activity is meant to remind students to make a picture when analyzing data.

Description: These data sets are from Workshop Statistics. I used to give the raw data and asked students to tell which had a Least Squares line that was a "better" fit. Since the datasets have the same correlation, many times the students would report that all lines fit equally well. If they looked at the graph, however, only one dataset was truly approximated well with a line.

An alternative activity with these datasets is to laminate the raw data, the scatterplots, and the least squares regression lines and ask students to match all three.

Spaghetti and Buckets of Pennies *(Handout)*

Purpose: Students develop regression model for non-linear (power function) relationship.

Description: A strand of spaghetti spans *n* centimeters off a table with a Dixie cup "bucket" hanging off. For different values of *n*, students determine how many pennies it takes to break the strand of spaghetti. It's important that students gently add pennies one-by-one to avoid breaking the spaghetti through shock or bounce. Note: The activity was originally designed to utilize Fathom for data analysis, but can be done with any graphing calculator with minor changes on the worksheet. With the data, students are guided to do a log-log transformation on the data to perform a linear regression. You can change this part to have as much or as little guidance as you desire. I provide a lot of guidance for my Pre-Calculus class, but change it to have very little for my AP Stats students.

Probability

3 Loops *(Workshop Activity)*

Purpose: Students construct a probability distribution based on experimental data and theoretical probability.

Description: Pairs of students get three strings about 10-12 inches in length. One student bends the strings in half and holds all three loops in her fist so that only the six ends show from the top of her hand. The other student randomly selects two ends and ties them together (square knot), then another two ends and ties them together, and then finally the last two ends and ties them together. Once all students have tied the ends, and before the release the strings, ask them what potentially happened. (1, 2, or 3 loops formed.) Ask them which outcome do they believe is the most probable. (Answers vary.) Ask them to release their strings to determine their outcome. Construct frequency and probability distribution for their experiment on the board. Finally, have students (in pairs or groups of 4) calculate the theoretical probability distribution for the situation. If groups need a hint, tell them to construct a tree diagram.

Play Card Independence *(Demonsration)*

Purpose: Demonstrate the difference between independent and dependent events.

Description: Do this demonstration as a whole class before speaking about the mathematical definition of independence.
I need a volunteer.

1. I choose a single card from a standard deck of cards. You can have a dollar if you can guess this card 2 through ace (no suit necessary). Student guesses on a small white board that is then flipped over and not shared.
    - Ask class, "What is the probability of having a correct guess?" (answer: 4/52)
2. For a penny, I'll give you a hint. The card is red.
    - Ask class, "What is the probability of having a correct guess?" (answer: 2/26)
3. For another penny, I'll give you another hint. The card is a heart.
    - Ask class, "What is the probability of having a correct guess?" (answer: 1/13)
4. For another penny, I'll give you one more hint. The card is a number.
    - Ask class, "What is the probability of having a correct guess?" (answer: 1/9)
5. Debrief about what information was helpful. Notes:
    - You can ask the probability questions as you go or at the end to highlight what information changes the probability from the beginning.
    - Talk about the informal definition of independence: How more information does not change probability of the event.
6. Now, go into example problems and mathematical definition of independence.

Bayes Incarcerated in Illinois? *(Handout)*

Purpose: Students calculate the probability of being incarcerated given a person is African American in Illinois using statistics published by the Pew Research Foundation in December 2007.

Description: This is a discussion that was useful in my class after Pew's research came out on Nov. 13, 2010. An article stated that, in Illinois, the probability of being black given a person is incarcerated is .63. Given only 15% of the state's population of around 12.8 million (US census, 2006), what is the probability of being incarcerated given you are black? Have students figure out what stats they need to answer the question via the formula for Bayes Rule.

Confidence Intervals

Polls - Approximating the True Population Proportion (*Workshop Activity*)

Purpose: Introduce confidence intervals. Reinforce the idea that we don't know the population parameter, but are trying to estimate it. Serves as a good reference point to remember that there is not a 95% probability that the true proportion is ____.

Description: Bags of beads, most of them translucent, but a some of them opaque, are given to pairs of students. I set the opaque proportion to a predetermined amount, and have students draw 50 beads from the bag one at a time *with replacement* to get a point estimate of the population proportion. They build a 95% confidence interval and interpret that interval for the true proportion in their envelope. Then students draw another 50 beads with replacement to calculate a confidence interval of n=100. Finally students draw another 50 beads to calculate a third confidence interval of sample size 150. Students then compare the confidence intervals' widths to come to a conclusion that they have decreased. At the end of class, I tell them the true proportions. The same experiment can be done by setting up envelopes with slips of paper, white and colored.

Notes: This activity is introduced with a recent poll. This year we used California Proposition 19 election results with polls preceding the election. See Wikipedia (http://en.wikipedia.org/wiki/California_Proposition_19_%282010%29#Polls)

Engaging Activities to Introduce Key Ideas in AP Statistics
NCTM 2013 Annual Meeting and Exposition

Hypothesis Testing

Loaded Dice (*Workshop Activity*)

Purpose: Students collect data on loaded dice and calculate the probability of getting their results given the dice were fair. This is a good discrepant event task that gets the students every time, and is a great introduction to the 1-sample proportions test.

Description: Each student rolls two dice together, (one green, one red -- cheap foam dice), ten times and record the number of times the green one wins. One of the dice is either loaded to roll a certain number or doctored to have two fives. Have students pass around paper and dice, completing the task while doing another activity. This way they will not notice anything strange with the dice, and it will not take up too much class time. The first student who completes the other activity will sum the number of wins by green. Once students have completed the primary task of the class, discuss the results of the dice rolling as a class. Ask students how they would determine the probability of getting results such as these given the dice were fair. Calculate the results as a class.

Lying with M&Ms *(Handout)*

Purpose: Students test the published proportions of each color of M&M using their bag of M&Ms using a Chi-squared Goodness of Fit test.

Description: A bag of M&M's is used to determine whether the published proportion of each color of M&M's is correct. On my worksheet, however, the proportions are incorrect because they were from 2003. Students end up with a large chi-squared, which makes students wonder whether the Mars corporation is miss-reporting the true proportions. At the end, have students go online to verify, thus revealing the real truth.

Hazelwood vs. United States (*Handout*)

Purpose: Students will re-create a historical event & defend their side (school district or U.S.) by running a hypothesis test on the true proportion of African-American teachers the school district should hire

Description: Students are presented with some historical context about the lawsuit over Hazelwood's racist hiring practice. The class is split in half, given the statistical information from the case and told they are a key witness as a statistics expert. One half gets to represent the school district (defendant) & other the U.S. (plaintiff). Students create their hypothesis test and then run a brief 'trial' where students present & defend their results.

Presenters: Scott Galson (sdgalson@cps.edu) and McKendry Marano (mkmarano@cps.edu)

Engaging Activities to Introduce Key Ideas in AP Statistics
NCTM 2013 Annual Meeting and Exposition

Are you a Super Taster?

Purpose: Students test to see if their classmate has the ability to differentiate Coke and Pepsi via a taste test and a one-sample proportions test. This is a great way to introduce hypothesis tests, and review randomized experimental procedures.

Description: Students are put into groups of 3 or 4 and one person (who enjoys drinking soft drinks) volunteers to be the taste tester. The taste tester is presented with three cups of cola: two are the same, and one is different (e.g. 2 are Coke, and 1 is Pepsi). The taste tester sips from each cup and decides which cup is the different cola. There are a lot of things about the procedure to think about. These include which cola is the different cola (Pepsi or Coke), the order of the colas being presented (i.e. which cup has the different cola: 1st, 2nd or 3rd), and how to implement a double blind procedure (the person giving the cups of cola to the taste tester, or interacting with the taste tester has no idea which cup is the different cola). Data is then analyzed to see if the taste tester has done better than guessing. Before the experiment is executed, there should be a discussion about the experimental design, how many trials are necessary, and methods for randomization.

Spinning Pennies – 1961 v. other years (*Workshop Activity*)

Purpose: Students are told that they are to conduct a one-sample proportions test to see if their penny has a 50/50 chance of landing heads up when spun on the desk. However, some students are given 1961 pennies are some are not. Data on spinning is then combined for all 1961 pennies and all other pennies to do a two-sample proportions test to see if the likelihood of spinning pennies is difference between the two populations.

Description: Each student is given a penny; about half 1961 pennies. Students spin the pennies 40 times and record the number of times the penny lands heads-up. (Note that some students will have to be taught how to spin a coin.) Then, students determine the probability of getting the sample proportion for their penny given the true proportion should be 0.5 given spinning a penny is fair. Finally, data is combined for all students with 1961 pennies and non-1961 pennies and a two-sample proportions test is run to determine whether the two populations' proportions are equal.

Notes: Activity is introduced in reference to the Super Bowl and the coin toss. What if there was a coin spin and not a toss? Also, 1961 pennies are easy to get. Over winter break, we have students bring in a 1961 penny for extra credit!

*** If you would like electronic copies of any of our materials, please email us!***

Presenters: Scott Galson (sdgalson@cps.edu) and McKendry Marano (mkmarano@cps.edu)