Teaching Statistics with Fictional Anecdotes

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ABSTRACT

The authors demonstrate that anecdotes are a simple, yet effective, way of communicating some major principles of statistics. Anecdotes are used to demonstrate various important statistical concepts including: the importance of obtaining a representative sample and achieving a high rate of response, the consequence of improper wording of questions, the usefulness of measures of dispersion, and why correlation does not prove causality.
Teaching Statistics with Fictional Anecdotes

Historian Andrew Lang said that some people use statistics "as a drunken man uses lampposts - for support rather than illumination." There has been a large increase of students enrolled in statistics classes in recent years. With the advent of calculators and computers, statistical analysis is occurring at an unprecedented rate and its study has become an essential component of high school and college education. The ability, interest, and motivation vary greatly among elementary statistics students. The purpose of this article is to demonstrate how fictitious anecdotes, especially humorous ones, can be used to effectively teach statistical concepts and to dispel some common misconceptions in statistics. More importantly, anecdotes can be used to demonstrate the relevance of statistics to everyday situations. This anecdotal approach is an especially helpful tool in motivating a diverse student body with a wide variety of mathematical backgrounds.

Representative Samples

(1) Millions of Alien Abductions?

Professor Ima Klutz is doing research on individuals who claim to have been abducted by aliens from another planet. Professor Klutz sent out 2 million questionnaires and 100,000 were returned by respondents. The questionnaire included such questions as: "In the last 30 days, how many aliens from other planets have you encountered?" Professor Klutz has cited his
research on various television talk shows. Based on his research, he claims that thirty percent of Americans have encountered aliens. Indeed, he insists that twenty percent of Americans claim to have been forcibly abducted, and ten percent of respondents claim to have been molested by these aliens from other planets. Professor Klutz's research was challenged by other panelists on the television show. Professor Klutz's response was that the Gallup poll and other well-known polls are based on samples of 2,000 individuals, whereas the Klutz study was based on 100,000 respondents.

Students are asked to think about this fictional anecdote and decide whether Professor Klutz's research is valid. This anecdote can be used to illustrate that it is not the number of responses that matter but the rate of response. Students can also be taught the important idea of representative samples. Respondents to surveys, in general, are overly interested in the subject of the questionnaire and those with little interest in the subject will often choose not to respond.

(2) Sample of 1,000?

The Hercules Juice Company purchases apples from various orchards. They have been offered apples from Aphrodite Apple Orchards at an excellent price. Professor Klutz is hired as a quality control consultant to determine whether the apples are sufficiently sweet for Hercules apple juice. Professor Klutz has determined that a sample size of 1,000 apples should be adequate. Professor Klutz arrives at the orchard and is told that the orchard consists of 25,000 trees and the typical tree has about 1,000 apples. He tells the Aphrodite people to pick apples
from a tree that he has selected randomly and bring him the apples. The apples are picked from one tree and brought to Professor Klutz. There are slightly more than 1,000 apples in the sample. Professor Klutz brings the apples to the Hercules Company for testing and the apples are perfect for juice. The Hercules Juice Company buys all of Aphrodite's apples. Subsequently, the juice produced by the company is found to be too tart and cannot even be given away, much less sold for profit. Professor Klutz is blamed. He is adamant in his claim that a sample of 1,000 apples is more than adequate for a representative sample.

A week later, Professor Klutz goes to the Hercules company doctor for a checkup. The doctor informs Professor Klutz that he needs a blood sample. The doctor takes a blood sample from the Professor's fingers, nose, ears, toes, knees, hips, lips, cheeks, buttocks, and elbows. Professor Klutz asks the doctor why he needs so much blood. The doctor, Dr. Mal Practice, informs the Professor that he wants a representative sample and he will not be satisfied with anything less than a sample of 1000. Professor Klutz is duly impressed.

This example illustrates that a sample of 1,000 from a perfectly homogeneous cluster may actually be the same as a sample of one. The blood supply of the human body is perfectly homogeneous and, thus, a sample from any part of the body is adequate. Similarly, the 1,000 apples coming from a single tree was actually an effective sample of only one.

Since apples from the same tree are homogeneous, one apple should have been randomly sampled from 1,000 different randomly selected trees in order to obtain a representative sample of 1,000.
(3) How Many Tax Cheaters?

Two researchers were interviewed on the Honey Money talk show. One researcher, Dr. Lane Payne, claims that his research shows that only 10% of Americans cheat on their Federal income taxes. The other researcher, Dr. Jack Asch, claims that his research shows that 90% of Americans cheat on their taxes. Dr. Klutz, a panelist on the show, is asked to determine whose research is more valid. He finds out that Dr. Asch used an anonymous mail survey with a 60% response rate; Dr. Payne used a telephone interview and achieved an 85% rate of response. Dr. Klutz's conclusion was that Dr. Payne's research is more likely to be valid given the higher rate of response.

This example demonstrates that the interviewing method can affect responses. Very few people are likely to admit cheating on their taxes to an anonymous telephone interviewer who claims to be working for a research company and may very well be an I.R.S. agent.

(4) Expert Interviewers?

Two different research companies are hired to determine whether illegal drug usage is a problem on campus. The ABC Research Company finds that 52% of students say they have used an illegal drug within the last thirty days. The XYZ Research Company, on the other hand, finds that only 13% of students claim to have used an illegal drug within the last thirty days. Dr. Klutz, consultant to the college, determines that both companies used personal interviewers.
However, ABC interviewers were students at the college and XYZ interviewers were mainly retired women who have worked for the company for the last several years. Dr. Klutz concludes that the XYZ company's research is more valid since they used professional interviewers, not novices.

This example illustrates the problem of interviewer effects. The age, sex, race, clothing, social class, vocal intonations, and mannerisms of the interviewer can affect the responses. Students are probably more likely to admit to drug usage to a fellow student wearing torn jeans and one earring than to an elderly woman in a conservative dress.

Wording the Questionnaire

(5) Roast Cardboard.

The Pecunious Research Company is hired by the Brown Shack hamburger chain to determine whether Brown Shack hamburgers are preferred to the hamburgers made by other fast food outlets. The Brown Shack hamburgers taste like dried cardboard but are baked (overbaked?) in an oven, not grilled. The question asked of a random sample of respondents is the following: How do you prefer your hamburgers: fried in greasy fat or roasted over a fire? The results show that 80% of respondents prefer their hamburgers roasted rather than fried. Brown Shack is citing this research in their advertising.
This example illustrates that the connotations of words can influence the responses. Words such as "fried," "greasy," and "fat" have negative connotations. This is similar to what actually happened when Burger King did a survey which asked individuals whether they preferred their hamburgers "flame broiled or fried?"

Measures of Dispersion

(6) Buying good chips.

Professor Ima Klutz has been hired as a consultant by the Atlas Computer Company. They manufacture a computer with a three year warranty, i.e., they will replace or repair any computer that fails within the three year warranty period. The current supplier of the chip which is the main component of their computer is Supplier X, and only about 3% of Atlas computers do not make it through the warranty period. Currently, the Atlas Company is being offered computer chips from two suppliers, Supplier X and Supplier Y. Professor Klutz tells the buyer to take a random sample of ten chips from each supplier's chips and calculate the mean life. The buyer informs Professor Klutz that the chips manufactured by Supplier X have an average life of 10 years and the average life of chips manufactured by Supplier Y is 20 years. Professor Klutz orders the buyer to stop purchasing chips from Supplier X and switch to Supplier Y. After switching to Supplier Y, the Atlas Company computers start failing at an alarmingly high rate. More than 50% of the computers break down in the warranty period and the company is about to declare bankruptcy. Professor Klutz is blamed for switching to a new supplier. He claims that
the new supplier's chips have an average life that is twice that of the old supplier. He offers to do additional consulting and discover the problem.

This example can be used to demonstrate the importance of measures of dispersion. Students can be shown the original data.

Supplier X chips, n = 10 (life in years):
10, 10, 10, 10, 9, 11, 10, 11, 9, 10
Mean = 10 years, range = 2 years, and standard deviation = 0.67 years

Supplier Y chips, n=10 (life in years):
40, 2, 37, 1, 0, 31, 49, 1, 38, 1
Mean = 20 years, range = 48 years, and standard deviation = 20.50 years

Students should be able to appreciate the necessity of utilizing measures of dispersion after thinking about this example. Students will note that 50% of Supplier Y's chips have an average life of less than three years. This example also illustrates the importance of sampling in quality control.

(7) Blackout.

The New York City Transit Authority has just purchased a brand new type of fluorescent light bulb. These bulbs have an average life of 5.10 years with a standard deviation
of 0.00. Dr. Klutz, consultant for the Transit Authority, recommends that on one Saturday evening between midnight and 5 a.m., when the number of riders is small, all the bulbs in the subway system should be replaced. A worker for the system suggest replacing 5% of the bulbs each Saturday evening for the next twenty weeks until all the bulbs are replaced. Dr. Klutz insists that it is cheaper and more efficient to replace all the bulbs at once. The Transit Authority listens to Dr. Klutz.

Question: Is Dr. Klutz causing a problem for the Transit Authority? Answer: This example illustrates that with a standard deviation of 0.00, all the bulbs will burn out at about the same time and the whole subway system will suddenly be plunged into darkness.

Levels of Measurement

(8) Twice as hot?

Mr. Hale Snowball, meteorologist for a prominent network, is reporting on the weather. The temperature in New York City is 60 degrees Fahrenheit and 120 degrees Fahrenheit in Las Vegas. Mr. Snowball remarks that it is twice as hot in Las Vegas as in New York. After the broadcast, Dr. Statlove informs Mr. Snowball that the fact that 120 degrees is double 60 degrees does not allow one to say that it is "twice as hot." Dr. Snowball's colleague, Dr. Klutz, disagrees and says that it is twice as hot in Las Vegas than New York City.
This example could be used to demonstrate the levels of measurement: nominal, ordinal, interval, and ratio. Only with a ratio scale, i.e., where there is a "true" zero, may one use ratios.

Probability

(9) Too many components?

The Prometheus Printer Company manufactures a laser printer made of 298 individual components. The warranty on their printers is one year, and they desire to reduce the failure rate (within the warranty period) of their printers to about 1%. Professor Klutz, their new consultant, orders buyers to purchase components from suppliers that have defect rates of no more than 1%. Subsequently, the Prometheus Printer Company discovers that 95% of their printers do not work. Professor Klutz claims that the suppliers have been dishonest about their defect rates and orders that all suppliers be fired immediately.

This example can be used to illustrate the idea of joint probabilities and might be useful as a way of introducing the concept of the binomial distribution. The probability of 0 defects with 298 parts and the probability of a defective is .01, is a binomial and is equal to 5%. There is a 95% chance that 1 or more of the components are defective. This example can be used to demonstrate that another way to improve quality is to reduce the number of components of a product.
(10) Buying a good scale.

Jane Seeless goes to a department store to purchase a scale to keep tabs on her weight. The store carries four different brands of scales, and Jane does not know which scale is more accurate. A friend suggests stepping on five or six different scales made by each of the four companies and recording the weight. Any brand whose readings are inconsistent should not be purchased. Only a brand that provides consistent readings should be considered. Dr. Klutz, renowned consultant, overhears the conversation and disagrees with the friend. Dr. Klutz asserts that even a brand that provides consistent readings might be providing consistently wrong readings. His suggestion is to simply buy the cheapest scale.

This example can be used to illustrate the concept of reliability and validity. If a measurement is not reliable, it cannot be valid. However, reliability does not guarantee validity. The scales that are not reliable should not be considered under any circumstance. Dr. Klutz got it almost right this time.
Statistical Inference

(11) Significant difference?

A hospital corporation is interested in knowing whether the average stay for their two maternity units is the same. They look at the records of every single maternity patient who stayed at the two hospitals in the last ten years (both hospitals were opened 10 years previously) and find that the average stay at Hospital X is 2.48 days (1506 patients) and 2.61 days at Hospital Y (1950 patients). The director of Hospital Y claims that this difference is not statistically significant. Management is unsure and hires Dr. Klutz. He performs a t-test on the data and concludes that the difference is statistically significant.

This example can be used to illustrate that statistical tests should not be used on a census. There is no sampling error when a census is taken and any difference, no matter how small, will be "significant," i.e., not due to sampling error. It is the job of management to determine whether the observed difference is of sufficient magnitude to warrant taking action or not.

(12) Cooling off.

Professor Ima Klutz has performed research demonstrating that there is a significant inverse correlation between the amount of clothing people wear and the temperature. There has been a terrible heatwave for several weeks. Professor Klutz has come up with a solution. He asserts that since there is a significant and strong negative correlation between the amount of
clothing and temperature, then everyone should go out wearing their heaviest winter clothing and it will get cooler.

Students are asked to think about this fictional anecdote and decide why Professor Klutz’s research is wrong. It should not take them long to realize that a correlation between A and B does not necessarily prove that A causes B. It is possible that B causes A, or that C affects both A and B. Sometimes correlations can be spurious. In this case, it is clear that the weather affects the amount of clothing worn, and not vice versa. In the past, Prof. Klutz has also recommended that farmers go out with open umbrellas in order to cause it to rain (sigh!).

In a similar vein, the following story has been circulating.

There was once a cholera epidemic in Russia. The government, in an effort to stem the disease, sent doctors to the worst-affected areas. The peasants of the province of S____ discussed the situation and observed a very high correlation between the number of doctors in a given area and the incidence of cholera in that area (i.e. more doctors were observed in cholera areas than elsewhere). Relying on this hard fact, they rose and murdered their doctors.¹

Clearly, the misapplication of statistics can be dangerous to one's health and life.