

THE STATISTICAL EDUCATION OF TEACHERS SET

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Statistics in Society

- The prevalence of statistics in the media, workplace, and education is increasingly widespread
- Quantitative literacy is a necessity for graduates who aspire to a wide range of positions and careers
- The study of data is interesting and engaging
 - ▣ Harvard Business Review called a “Data Scientist” the sexiest job of the 21st century



Statistics in Education

- The NCTM Standards included a Probability and Data Analysis strand
- The American Statistical Association sponsored the writing of the Guidelines for Assessment in Statistics Education (GAISE) PreK-12 and College Reports
 - Among other things, this report made headway in differentiating between mathematics and statistics

“Statistics is a methodological discipline. It exists not for itself, but rather to offer to other fields of study a coherent set of ideas and tools for dealing with data.

The need for such a discipline arises from the omnipresence of variability”

▣ Moore & Cobb, 1997

Differences between Mathematics and Statistics

- Statistical problem solving and decision making depend on understanding, explaining, and quantifying the variability in data
- Statistics *uses* probability but does not study it
 - ▣ Statistics uses probability to quantify variability and to build sampling distributions
- Statistics relies on context
 - ▣ “Statistics requires a different kind of thinking, because data are not just numbers, they are numbers with a context. In mathematics, context obscures structure. In data analysis, context provides meaning.” ~Moore & Cobb, 1997

Common Core



- The Common Core State Standards place a large emphasis on statistics in the middle- and high-school grades
- The statistics included in the Common Core is welcomed and needed
- The Common Core makes it a very exciting time for statistics education with many opportunities as well as many challenges

Statistics in the Common Core

- The presence of statistics in elementary school is important but is limited
 - ▣ It is important to prepare elementary teachers to reason statistically to lay the groundwork for their students to move successfully to the middle grades
- Main topics in middle school include
 - ▣ Statistical variability
 - ▣ Distributions
 - ▣ Drawing inference about populations using samples
 - ▣ Simulations
 - ▣ Bivariate data analysis
- Main topics in high school include
 - ▣ Categorical and quantitative data analysis
 - ▣ Inference
 - ▣ Conditional probability and probability rules
 - ▣ Probability for decision making

Huge Opportunities

- Statistical Literacy for ALL
- In higher education, this also affords us opportunities to rethink college courses in statistics

Huge Challenges

- Preparing K-12 teachers to deliver the statistical content in the CCSS – both pre-service and in-service teachers
- Rethinking the college intro course and the second course in statistics
- Are colleges prepared for the increased number of students wanting to major and minor in Statistics?

Teacher Preparation

□ MET 2

- Recommends a statistics course beyond intro statistics for middle school teachers
- Recommends a modern day one or two intro course sequence for high school teachers
- These courses should all emphasize concepts
- The courses should utilize activities and technology

The Statistical Education of Teachers (SET)



- Writers:
 - ▣ Christine Franklin
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 - ▣ Richard Schaeffer
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The Statistical Education of Teachers (SET)

- The report emphasizes that teachers of all grade levels need to understand the “statistical process”

- Formulate statistical question
- Data production
- Data exploration and modeling
- Inference



- The statistical process components are the common headings in the three chapters (elementary, middle, and high) of SET

Connections

- We want teacher preparation in statistics to be connected throughout the grade bands
 - ▣ Elementary → Middle → High
- We want content at each grade band that will progress teachers through the statistical thinking process
- Lets look at an example that can be used in each grade band differently to develop the appropriate skills of the level

Example Illustration: Bottled Water

- A newspaper article recently stated that bottled water consumption is on the rise
- Elementary: What type of water (bottled or tap) is most popular among students in our class?
- Middle: Are people more likely to select bottled water than if selecting a cup at random?
- High: Same question as the middle school (different techniques to solve it)

Bottled Water Elementary

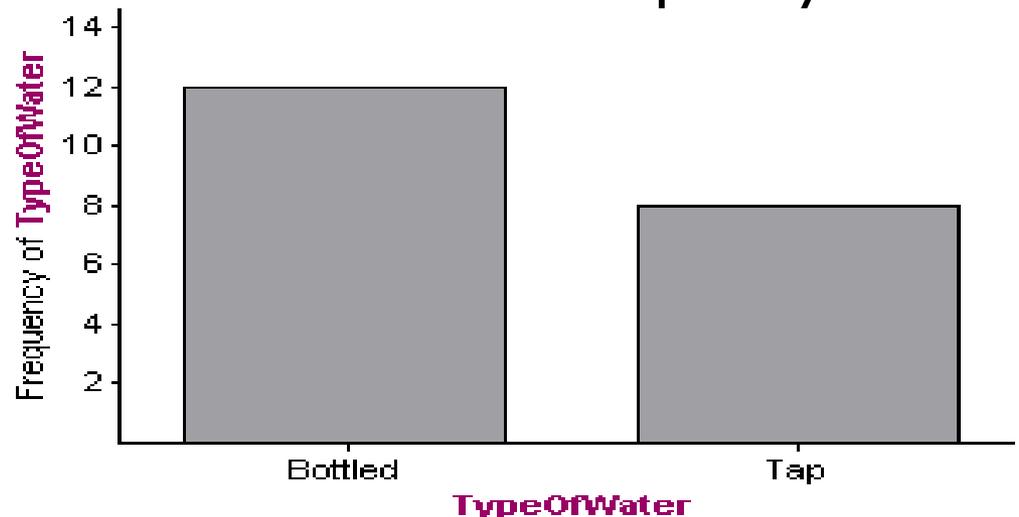
What type of water (bottled or tap) is most popular among students in our class?

- Teachers should
 - discuss how to gather class data to answer this question paying particular attention to the categorical nature of “type of water”
 - discuss why these data should be gathered
 - go through the data generating procedure
 - graphically represent their data using a pictograph, histogram, frequency count table, etc.
 - make observations about which type of water is most popular for the class by observing the modal category
 - consider whether the classroom results could be inferred to different classrooms or other groups
 - answer the question and support their answer

Bottled Water Middle

Are people more likely to select bottled water than if selecting a cup at random?

- Teachers should
 - ▣ Set up a classroom experiment that tests bottled water versus tap
 - ▣ graphically represent their data in a frequency table or bar graph

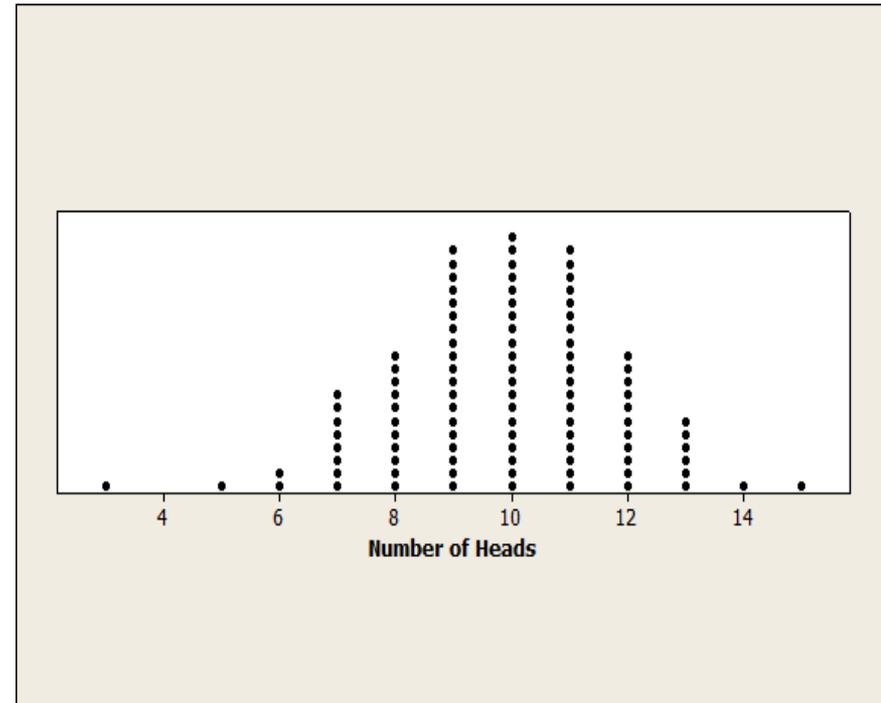


Bottled Water Middle Continued

Are people more likely to select bottled water at random?

Teachers should discuss the likelihood of obtaining the result of “12 out of 20” preferred bottled by setting up a model for exploring the long run behavior of the number of people that prefer bottled water when the selection is random

- This could be done by simulating a coin flip where the number of heads represents the number of people that prefer bottled



Bottled Water High

Are people more likely to select bottled water than if selecting a cup at random?

- Teacher should
 - ▣ Carry out the same exploration as the middle school teachers
 - ▣ Go beyond to formalize the procedure by
 - Translating the question into a null and alternate hypothesis
 - Understanding how the binomial distribution provides a mathematical model for describing random variation in the “number of people preferring bottled”
 - Determining the p-value associated with the observed statistic
 - Describing the strength of evidence against the notion that the selection is random

Recommendations for Elementary Teacher Preparation

- SET recommends that elementary teachers take
 - ▣ A special section of an intro course
 - OR
 - ▣ An entire course in statistics content for teachers
 - OR
 - ▣ A reconfiguration of an existing content course for teachers to include at least 6 weeks of study of statistics and related ideas in probability

Recommendations for Middle Teacher Preparation

- SET recommends that middle school teachers take
 - ▣ A special section of an intro course

AND

- ▣ A course focused on the statistical content they will be teaching using the GAISE framework as a model
 - This course should also help teaches understand connections across grade bands as well as between statistics and other areas of study in middle grades (mathematics, science, social science, etc.)

Recommendations for High School Teacher Preparation

- SET recommends that high school teachers take:
 - An introductory course that emphasizes modern data analysis, simulation approaches to inference using the appropriate technologies
 - A statistical modeling course based on multiple regression, including the use of both categorical and numerical explanatory variables and the fitting of exponential and power models
 - A course exposing high school teachers to the theory of statistical inference through one- and two-sample classical inference procedure and an introduction to analysis of variance

Summary of “Courses”

- Elementary
 - 6 weeks to 1 course
- Middle
 - 2 courses
- High
 - 3 courses
- These recommendations are consistent with the MET II report

The Intro Course

- The standard college level intro stat course is *not* adequate for teacher preparation
- SET recommends a modern day intro course emphasizing (1) data analysis and simulation approaches to understanding inference, (2) more on modeling, and (3) statistical theory that ties in with probability theory (e.g., the use of conditional probability in contingency tables and the chi-squared test)
 - ▣ The current typical standard course tends to be formula-based, going through the list of hypothesis tests and probability theory somewhat removed from the statistical concepts being covered

What Should Math Departments Do?

- Carefully examine the intro course to see how it can be reconfigured to meet the needs of teacher preparation possibly opening up a specific section of the course for all K-12 teachers
- Additional teacher coursework can be tailored to the grade levels a teacher will be teaching
- Work collaboratively with statisticians with experience in statistics education to design courses