Early Introduction to Hypothesis Testing

Shellene C. Foster

Timeline

- Departmental final exam highlighted low understanding of hypothesis testing (fall 2008)
- A professor at the joint Statistical meetings pointed out that the most logically challenging material should be taught from day 1 giving students more time to master it. (summer 2009)
- Informally began teaching hypothesis testing entire semester fall 2009 & spring 2010.

Timeline Continued

- Student perceptions of the pilot were encouraging enough to formalize materials into both in-class labs, and written labs (summer 2010)

- Future goals include rewriting labs to include more engaging experiments and data sets.

Written Labs

- Written Labs are for students who miss class on a Lab day.

- All other students have Lab topics presented and practiced in class.

Week 1: The Basics

- Lab 1
- Objectives:
  - Define **inferential statistics**
  - Identify **population of interest and samples**
  - Classify data as **parameter or statistic**
  - Write complete research statements
  - Formally state the **null hypothesis** and the **alternative hypothesis**
  - Identify factors that affect the strength of sample evidence

- Chapter 1
- Partial Objectives:
  - Understand **descriptive** and **inferential statistics**
  - Differentiate between **populations** and **samples**
  - Identify **parameters** and **statistics**
  - Identify research goals
  - Understand various sampling methods..

Week 1 Detail

- Which of the two following scenarios provides stronger evidence to support the research question?
  - I. The republican candidate's manager believes that he will win the election in November. In order to support her belief, she randomly surveys 500 voters. Of the 500 voters, 62% state they will be voting for the republican candidate.
  - II. A school board candidate wants to know if she should continue in her efforts to be elected at the next election. If she currently has more than 30% of the vote, she will continue in her efforts to be elected. In a sample of 10 school board attendees, 3 state that they would vote for her.

Week 2: How do sample proportions behave?

- Lab 2
- Objectives:
  - Discover how **sample proportions** behave
  - Graph and interpret **frequency distributions** and **relative frequency distributions** for sample proportions
  - Define **unbiased estimators**
  - Intuitively define which results are **usual/unusual**?
  - Draw conclusions using the **rare event rule**
  - Properly phrase final conclusions for hypothesis tests..

- Chapter 2
- Partial Objectives:
  - Identify bell shaped and skewed data sets
  - Graph **frequency distributions** and **relative frequency distributions.**

Week 2 Detail

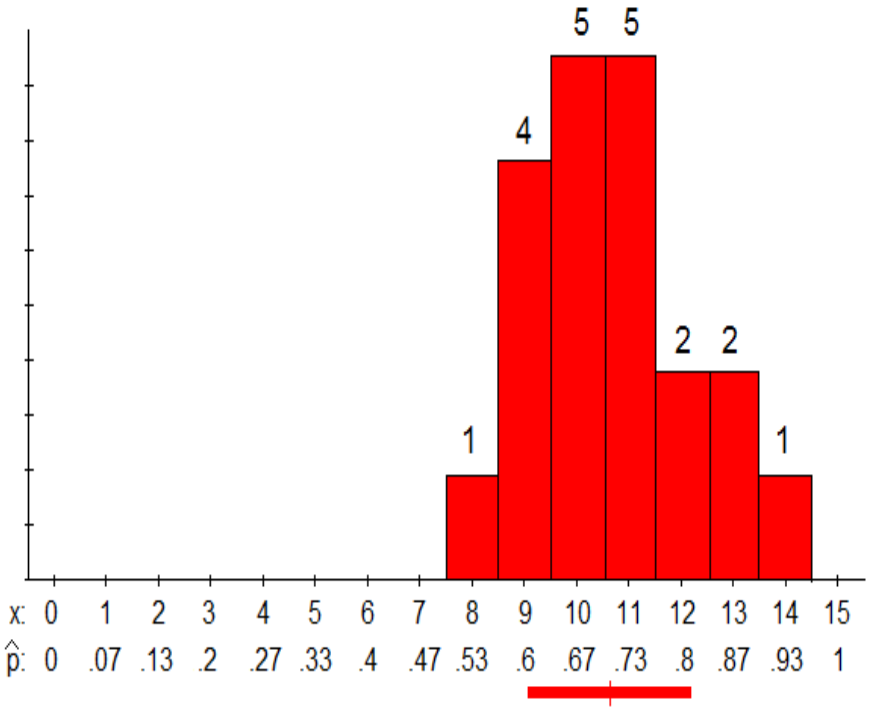
- Inferential Statistics collects data only from a sample, and then infers conclusions about the unknown population
- We will experiment with pennies. The unknown parameter is the proportion of tosses that will show heads.
- Everyone will toss their penny 20 times, and calculate the sample proportion of heads tossed. We will compile these results to learn how the sample proportions behave.

Week 3: Review and Practice

- Lab 3
- Review:
  - Estimate population proportion from a collection of sample proportions
  - Research about standard deviations
  - What sample evidence would be unusual enough to reject the null hypothesis?.

- Chapter 3
- Partial Objectives:
  - Calculating mean of data sets and frequency distributions
  - Standard deviation
  - usual/unusual data with mean ± 2SD.

Week 3 Detail



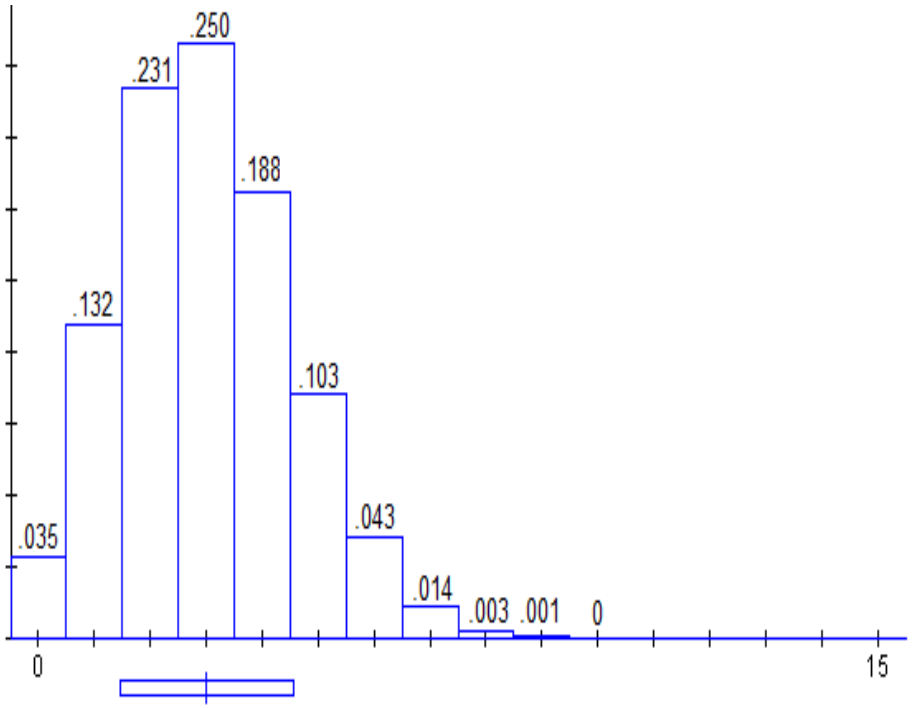
- Answer the following questions:
  - For each experiment, find the value of n
  - How many experiments are represented in the graph?
  - How many experiments showed 9 heads in 15 tosses?
  - How many experiments showed a p-hat value of 0.8?
  - Create a relative frequency histogram for the collection of experiments.
  - What is the best estimate you can give for the true population proportion of heads for this trick coin?
  - How could you get a better estimate of the true population proportion of heads for this trick coin?
  - Would it be usual or unusual to witness 9 heads in 15 tosses with this trick coin?

Week 5: Probability Distributions

- Lab 4
- Objectives:
  - Calculate basic probabilities
  - Interpret probabilities as **rare or highly likely**
  - Use the **5% rule**
  - Read and interpret probability distributions
  - Calculate probabilities for the rare event rule..

- Chapter 5
- Partial Objectives:
  - Calculate probabilities
  - Use probabilities to identify rare and highly likely events
  - Use the 5% rule for rare events
  - Use probability models.

Week 5 Detail (1)



- n has what value?
- Estimate the mean x value.
- Estimate the value of p.
- Fill in the missing p=hat values on the graph.
- Find P(x=4).
- Find P(p-hat = 1/3).
- Find P(p-hat = 1/3 or p-hat= 2/5).
- Find P(p-hat<= 1/5). Would it be rare for p-hat to be less than or equal to 1/5?
- Find P(p-hat>= 2/5). Would it be rare for p-hat to be greater than or equal to 2/5?
- Find P(p-hat<= 1/5 or p-hat>= 2/5). Would it be rare for p-hat to be less than or equal to 1/5 or greater than or equal to 2/5?

Week 5 Detail (2)

- In 2001, 20% of American university undergraduate students had at least one tattoo. A health practitioner suspects that the percent has increased since then. She obtains a random sample of 15 university undergraduate students and finds that 6 have at least one tattoo. Answer all of the following questions:
  - Write the research question.
  - Write the null and alternative hypotheses.
  - What should be assumed to be true in order to construct the theoretical probability distribution for this test?
  - Use the provided theoretical probability distribution to calculate P(x>=6).
  - Use the 5% rule to decide if 6/15 is far enough away from the expected 20% that we should reject the 20% as no longer reasonable.

Week 6: Errors (part 1)

- Lab 5
- Objectives:
  - Identify types of **errors** in tests of hypotheses
  - Equate the rejection rule with the probability of a **type I** error
  - Reduce the rejection rule in cases where the consequences of a type I error would be severe..
- Chapter 5
- Probability Continued

Week 7: Errors (part 2)

- Lab 6
- Objectives:
  - Intuitively define the **power** of a hypothesis test
  - List ways to increase the power of a hypothesis test
  - Understand the relationships between P(type I error), rejection rule, P(type II error), and power..

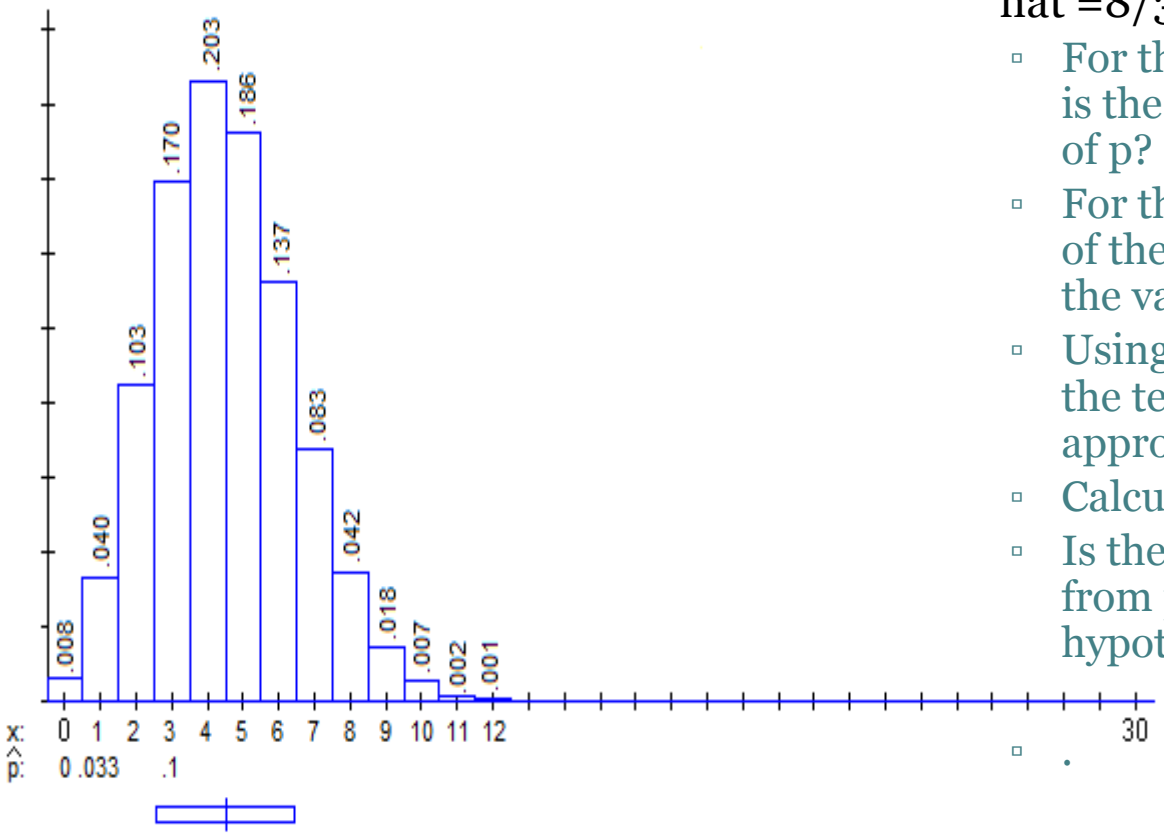
- Chapter 6
- Partial Objectives
  - Discrete probability distributions
    - Calculate means/expected values
  - Binomial distributions
    - Definition
    - Calculate binomial distributions
    - Calculate cumulative binomial probabilities
    - Requirements for binomial to be bell shaped
    - Mean/SD/Usual/Unusual

Week 9: P-values

- Lab 7
- Objectives:
  - Define P-value
  - Calculate P-values from given probability distributions
  - Interpret P-values as rare or not rare
  - Use P-values to draw final conclusions in tests of hypotheses
  - Perform all steps of a formal test of hypothesis
  - Define and employ **level of significance** in hypothesis testing
  - Identify **observed statistics** and **test statistics** in tests of hypothesis..

- Chapter 7
- Partial Objectives
  - Normal Distribution.

Week 9 Detail



- H0: p= 0.15, H1: p>0.15 A random sample of 30 subjects results in p-hat =8/30
  - For the implied distribution, what is the value of n? What is the value of p?
  - For this scenario, what is the value of the observed statistic? What is the value of the test statistic?
  - Using the given distribution, shade the test statistic and the appropriate tail.
  - Calculate the P-value.
  - Is the observed statistic far enough from p=0.15 that the null hypothesis can be rejected?
  - .

Week 10

- Lab 8
- Objectives:
  - Identify correct distribution for small sample tests of proportion
  - Understand the Binomial Distribution
  - Construct Binomial distributions for small sample tests of proportion
  - Apply Binomial distributions to formal hypothesis tests of proportions
  - Apply Normal distributions to formal hypothesis tests of proportions

- Chapter 8
- Partial Objectives
  - Central Limit Theorem
  - Normal distribution for the sample proportions.

Week 10 Detail

- **Part I**
- In 2009, students at 2 year institutions of higher education constituted 40% of all students in higher education according to the Bureau of Labor Statistics.2
- A conference administrator believes that students from 2 year institutions are underrepresented at his student research conference.
- During the conference, to quickly check his notion, he randomly selects 12 attendants and finds that only 1 attends a 2 yr institution.
- Does it appear that the 2 year institutions are underrepresented at his conference?

- **Part II**
- The administrator feels that the results from the small sample test of hypothesis warrants further study.
- For the larger study, he randomly selects 50 attendants and finds that only 15 attend a 2 yr institution.
- Does this larger sample indicate that the 2 year institutions are underrepresented at his conference?

Results

- Identify the null hypothesis:

2008	2009	Summer 2010
no early introduction	informal early introduction	formal early introduction
81%	78%	85%

Results

- Identify the alternative hypothesis:

2008	2009	Summer 2010
no early introduction	informal early introduction	formal early introduction
85%	81%	89%

Results

- Calculate the Test Statistic:

2008	2009	Summer 2010
no early introduction	informal early introduction	formal early introduction
64%	54%	96%

- If you count “z=test statistic value” correct along with “t=test statistic value” correct, then 2009 becomes 82%.

Results

- Calculate the P-value:

Fall 2008	Fall 2009	Summer 2010
no early introduction	informal early introduction	formal early introduction
50%	54%	88%

- If you count normal distribution P-value correct along with Student T distribution P-value correct, then 2009 becomes 82%.

Results

- Reject/Fail to Reject Ho:

Fall 2008	Fall 2009	Summer 2010
no early introduction	informal early introduction	formal early introduction
68%	84%	81%

Results

- Interpret the Final Conclusion:

Fall 2008	Fall 2009	Summer 2010
no early introduction	informal early introduction	formal early introduction
49%	70%	73%

Fall2009 Summer 2010 Student Perceptions

- 0=Strongly Disagree 5 = Strongly Agree

- Early Introduction of hypothesis testing made it easier to understand…

Topic	2009	2010
P-values	4.0	3.9
reject/fail to reject null	4.2	4.2
support/fail to support alternative	4.3	4.0
real world conclusions to tests	4.1	3.9

2009 Student Perceptions Detail

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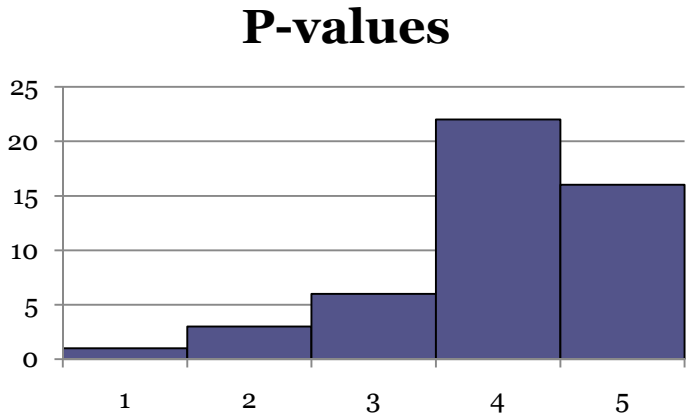

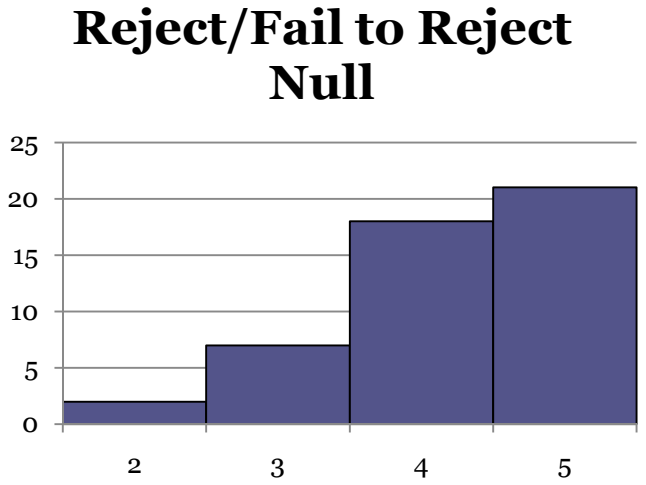

2009 Student Perceptions Detail

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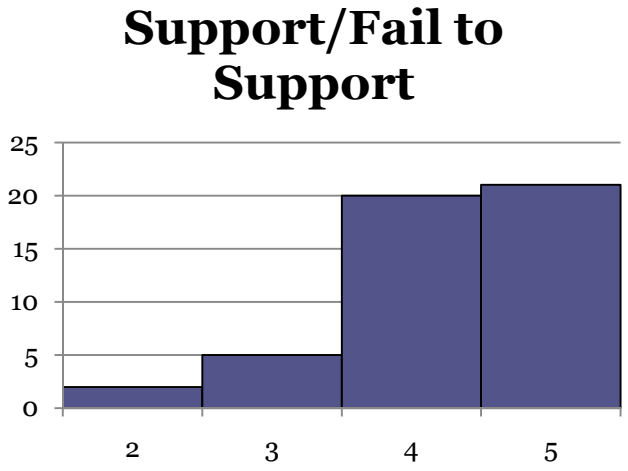

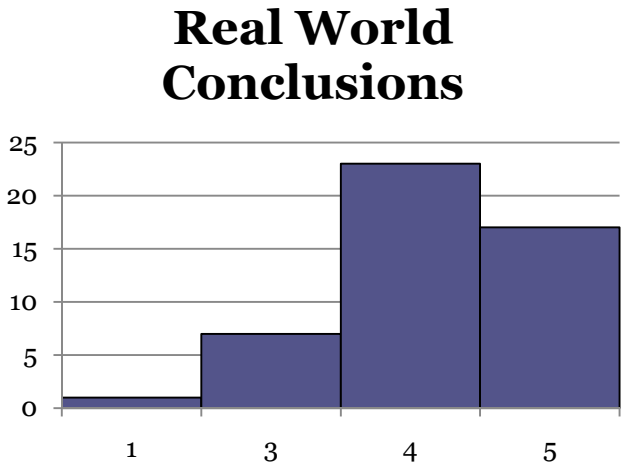

- sfoster@collin.edu

- Subject: Early Introduction of Hypothesis Testing