Session S.3.1
A Hands-On Experiment Comparing the Tastes of Two Competing Products

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Our elementary statistics class uses both lecture and hands-on lab experiments.

10-11 lab experiments showing statistics as a problem solving tool.

This session demonstrates one of these experiments.

More about course tomorrow.

The Setting:

You work for Cheaper Cracker, Inc.

Cheaper Cracker sales are low compared to Nabisco.

CEO Sam Cheaper wants to know if the problem is inferior taste.

What factors affect which brand of crackers that a consumer buys?

Our Tasks:

Plan and perform experiment comparing tastes of Cheaper and Nabisco crackers while eliminating all other factors.

Analyze data and report results to CEO Sam Cheaper.

Planning the Experiment:

How do we do an experiment that compares taste while eliminating all other factors?

Single-Blind Experiment:

Subjects close eyes.

Subjects taste the two brands in random order without knowing presentation order.

Subjects declare which cracker they prefer.

Warning

Some individuals have serious medical reactions to certain foods.

Feel free to ask me about the ingredients.

Participation as a subject is voluntary.

Performing the Experiment:

Subject approaches desk.

After closing eyes, subject tastes both brands in random order.

Tell me which (1st or 2nd) tastes better. Take additional bites if necessary.

Do not influence other subjects.

Binomial Experiment:

Success = choosing Cheaper

n = ___ subjects

p = P(randomly selected subject prefers taste of Cheaper Crackers)

X = # choosing Cheaper has a binomial distribution with parameters n and p.

$p < 1/2$, Cheaper tastes worse

$p = 1/2$, equally preferable

$p > 1/2$ Cheaper tastes better

Small values of X suggest that $p < 1/2$, i.e. inferior taste is a problem.

Data Analysis:

Prefer Cheaper _____ Point estimate of p = __ / ___ = _____

Prefer Nabisco _____ $P(X \leq \_\_ \mid p = 1/2) =$ _____

Total

Reporting Results:

Formal report or responses to short answer questions.

Short answer questions:

What made this a single-blind experiment?

Why didn't we tell subjects the order of presentation?

What proportion of sample preferred Cheaper? What does this suggest?

If the brands are actually equally preferable, what is the probability that as few or fewer subjects would have chosen Cheaper?

Do you think it unlikely that the brands are equally preferable in terms of taste?

What action should the CEO take based on these results?

Explain how a similar experiment could be done to compare the effectiveness of two suntan lotions.

In our classes, students divided into 6 teams.

Each team runs a test: Colas, saltine crackers, peanuts, cheese crackers, facial tissue, vanilla wafers.

Students are subjects in all tests.

Each team makes an oral report.

Some generic products are inferior and some are not.

5.7.2

Lessons Learned in 10 Years of Hands-On Learning at the University of South Carolina

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Ten years ago we began using hands-on experiments in elementary statistics.

This talk will discuss:

Motivation for using labs

How we do it

Obstacles overcome and lessons learned

Success stories

The 1990 Situation:

100% lecture based class

Enrollments good

Teaching evaluations positive except for complaints about computing exercises

Everybody happy, except me

Motivating Experiences:

Mr. Wizard and Square One

Need for memorable experiences

Negative experience in physics lab

Students panning existing computing component

Discussions with employers

Close Look at 1990 Course:

Little sense of how data are collected or why experiment is important

Experiments and data were words and numbers in text

Statistics = plug and chug

Leave course not knowing what statisticians do or role of statistics in science

Little exposure to

sample selection	operational definitions
data collection	experimental design
randomization	model building
factor selection	

No team activities

Low expectations for writing
Many think first course not fun or important

Why would they want to take a second course?

We could and must do better!

Lori Thombs, Don Edwards, and I decided to develop hands-on experiments

Goals of Lab Component:

Show important concepts of stat with fun experiments

Show statistics is important in science and business

Show tasks statisticians do

Stat computing without tears

Improve technical writing

Develop teamwork skills

How We Do It:

10-11 2-hour labs

31-32 days for lecture/exams

Lab 1: Intro to Minitab

Other Labs: Student teams

Discuss, design, & perform experiments

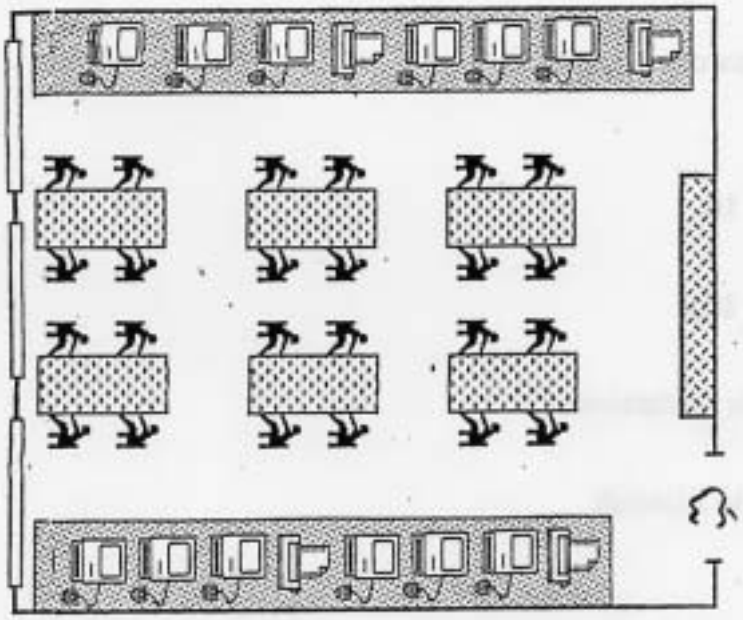
Collect and analyze data

Oral & written report

Facilities for 24 students:

36'×24' room with white board

12 computers circle room,	2 printers
6 workspaces in center	storage cabinet
television and vcr	small refrigerator



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Measurement Equipment:

Scales Calipers

Tape Measure Rulers

Stop watches

Experimental Supplies:

Embroidery hoops, Weights, Hickory nuts, Egg cartons, Buckets, Balsa airplanes, etc.

Experiments:

Combine statistical topics

Inexpensive and safe

Simple science

Discuss 1 experiment here

More details in breakout

Predicting Weight of Nut:

Team given 24 hickory nuts

Weight nuts on scale

3 dimensions with caliper

Statistical concepts

operational definitions, scatter plot, correlation
outlier, regression, compare models

Predict weight of 3 other nuts

Student Reports:

Teams make oral reports

Each student writes report

Short answer lab report using complete sentences

or formal written report

Obstacles Overcome and Lessons Learned:

Needed lab manual
NSF support

Statistics: Learning by Doing
by John D. Spurrier, Don Edwards, and Lori Thombs

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Equipment and supplies

What do you buy?

Who sells it?

Mostly Wal-Mart and hardware stores

Scientific equip. co.

Who supplies the money?

Initially grants

Now lab fees

Purchasing paperwork?

Pain in the _____

Different Class Environment for Teacher

Teacher as facilitator

Introduce lab, then ?

Go from team to team

asking and answering

questions

Ask questions as teams

collect and anaylze data

Different type of prep

Different Class Environment for Students

Late, unprepared, or absent students hurt others

Solved by lab quizzes

Teammate conflicts

State expectations

Assign and rotate teams

If you allow it, student can get by without thinking

Different Type of Grading

Initially, neither we nor the students knew what we expected in a written report

Clearly state expectations

Show examples of good work

Give students a checklist

Develop a grading rubric and make it available to students

1-2 formal reports is enough

More Hours or Less Material

11th Commandment

Statistics is a 3-hour course

Optional lab had few students

Fit lab into existing course

From 14 to 10 or 11 labs

Cut one exam

Reduce hand calculation

Some topics only in lab

Few topics no longer done

Moving to Multiple Sections

Initially, 1 honors section. Now 20 sections per semester

New experience for teachers

Training is needed
- Role of teacher
- Practice experiments
- Equipment
  - Using, storing, maintaining
- Safety

Checklists
- Before lab day
- Before students arrive
- During lab
- After lab

Lab notebook

Responsibility for reporting equipment or computing problems

An irresponsible teacher hurts other teachers

Suggested improvements

Teaching assistants had trouble introducing labs

We made short videos to do this.

Importance of Oral Reports

All students experience
work of all teams.

Weaker teams see examples of higher quality work.

Illustrates that some experiments are successes and others are failures.

Experience talking about technical ideas

Observe sampling error

Some Success Stories:

Students

Identify with data

Discover difficult concepts

Computing is important

Statistics is fun

Statistics is powerful tool

Improve as writers

Work in teams

Teacher must put in the effort

Session S.8.1

More Hands On Experiments Used at the University of South Carolina

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Our elementary statistics class uses both lecture and hands-on lab experiments.

10-11 lab experiments showing statistics as a problem solving tool.

Experiments combine topics.

This session highlights three of these experiments.

Real & Perceived Distances:

Prerequisites:

scatterplot, mean, median

Concepts Illustrated:

scatterplot	bivariate relationships
regression	calibration
measurement errors	outliers
mean versus median	variability among subjects

Outdoor Data Collection:

6 teams of 3-4 students

Students silently guess the distances to the nearest foot from a fixed reference point to each of 13 landmarks.

Landmarks are trees, fire hydrants, benches, sign posts.

True distances vary from about 4 to 300 feet.

Easy to guess short distances, long distances harder.

Landmarks 1 and 2 have short distances.

Landmark 13 is an intermediate distance.

Half long distance landmarks have odd numbers to facilitate measurement.

Odd (even) numbered teams measure distances to nearest inch to landmarks 1, 3, 5, 7, 9, and 11 (2, 4, 6, 8, 10, and 12) with a 50 foot tape.

Distance to landmark 13 is not measured by students.

Distances longer than 50 feet require teamwork skills to get an accurate measurement.

Data Analysis:

Variation in 3 measurements to the same landmark.

Outliers are common.

What caused this variation?

Should we use mean or median?

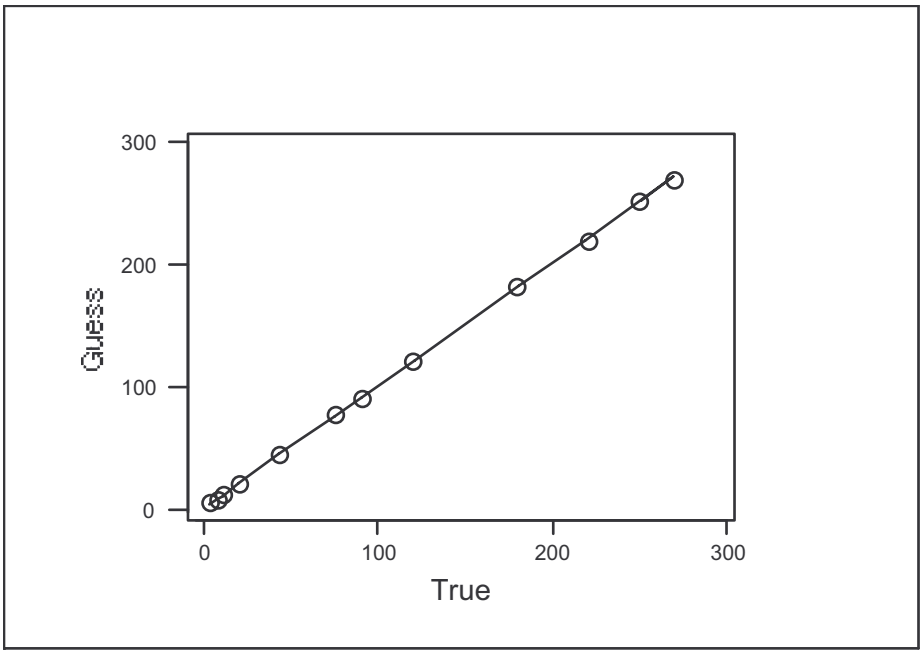
"True" distance = median

Each student makes scatter plot of guesses versus true distances for landmarks 1-12 with 45 degree line on plot.

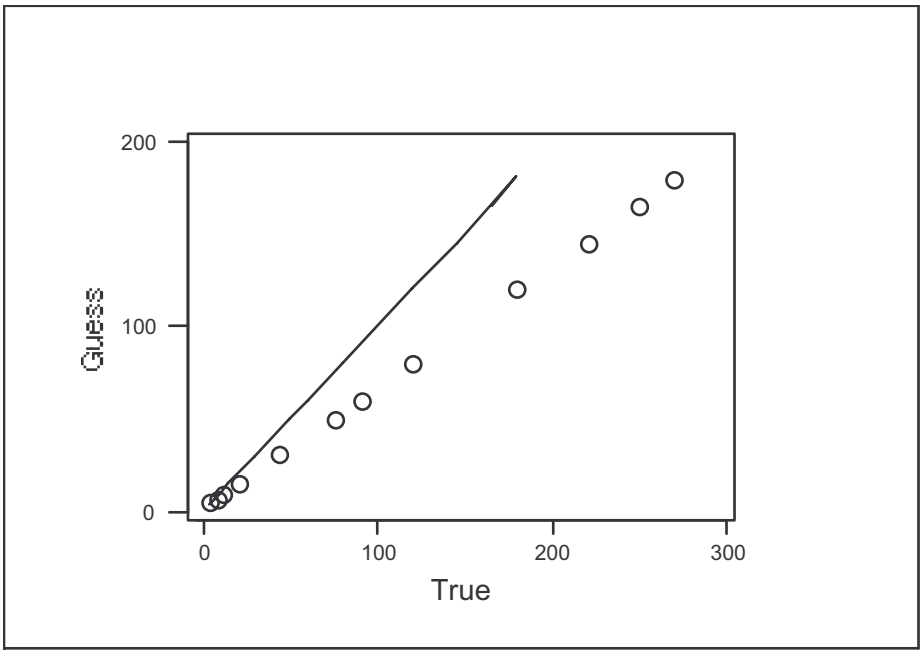
Most scatter plots show a strong relationship between the two variables.

Patterns vary greatly from student to student.

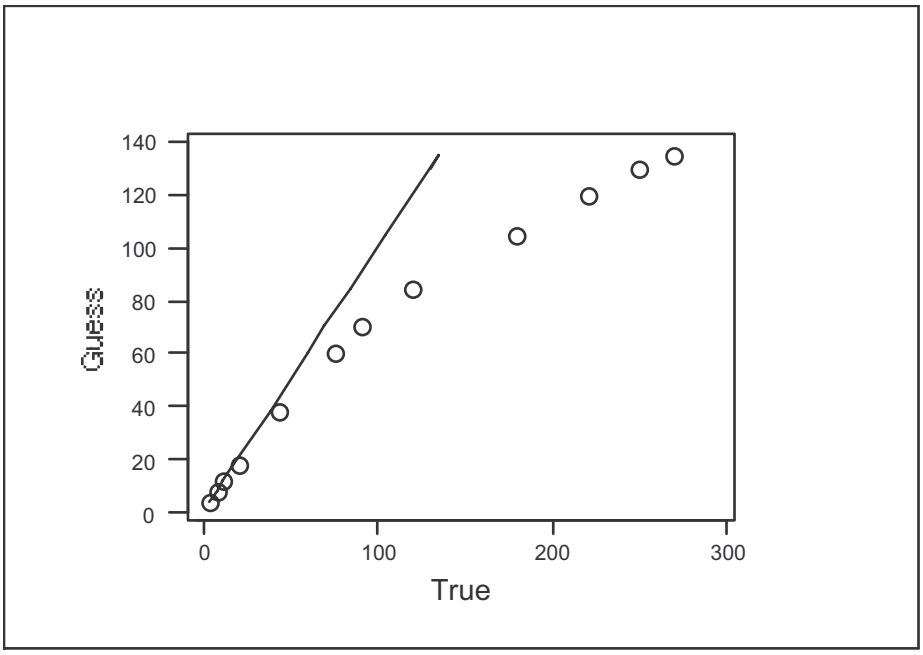
Linear, Unbiased



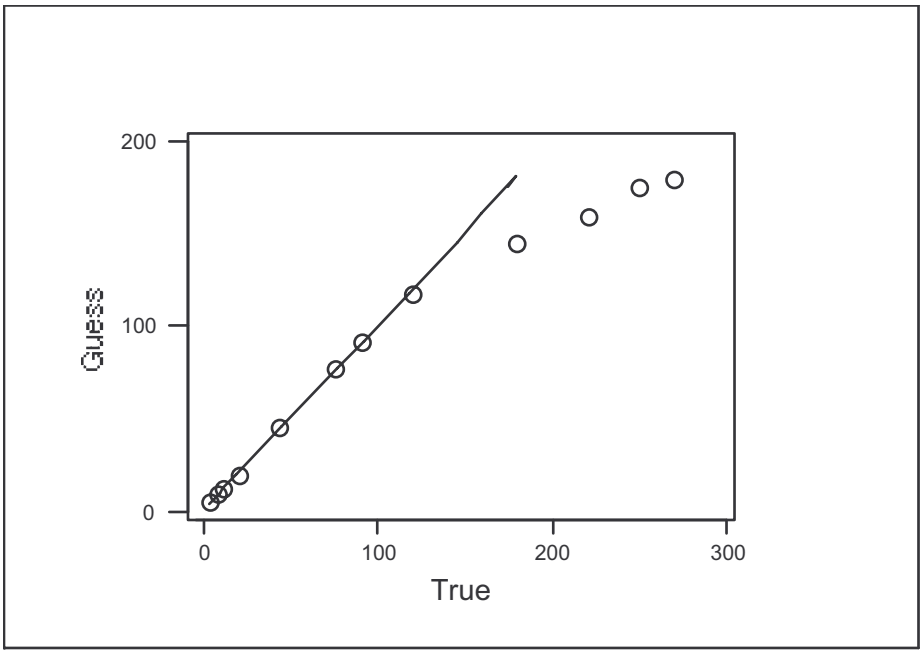
Linear, Biased



Non-linear



Mixed Method



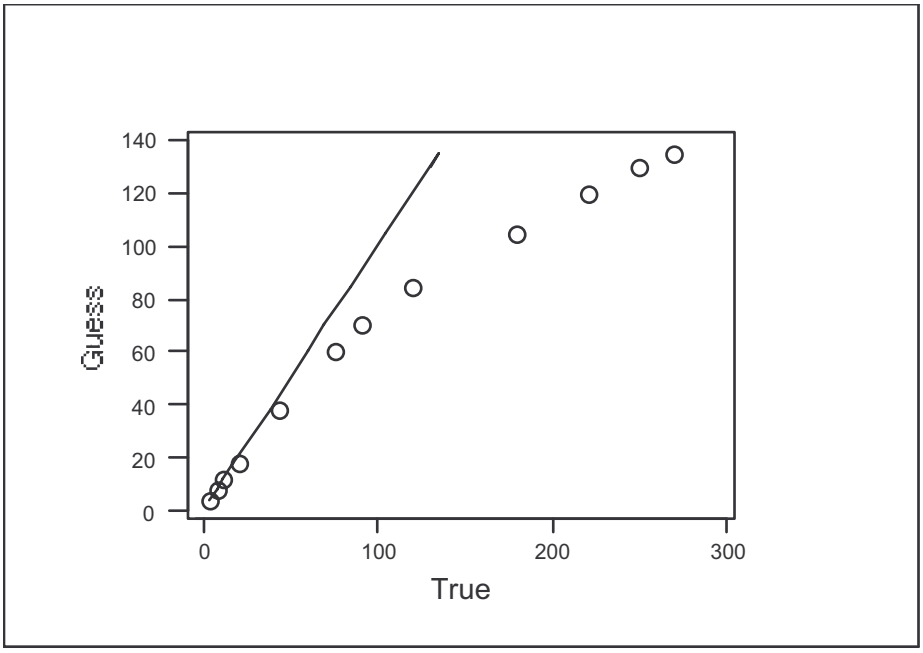
Students draw the line or curve that best fits their data.

What does your scatter plot tell you about your guessing ability?

Is your pattern linear?

Students with different patterns make oral reports.

Students use calibration to adjust their guess to the landmark 13 and report original and adjusted guess



Original Guess = 80 feet
Adjusted Guess = ___ feet
Do you think your adjusted guess is better than your original guess?

Most students adjusted guess is better than original guess.

Indoor Data Collection:

Guess lengths of lines drawn on 13 pieces of poster board to nearest inch.

Measure to nearest eighth of an inch with ruler.

Student Reaction

Making good measurements is harder than first thought.

Scatter plot shows pattern.

Some patterns are linear and others are not.

Many bad guessers just need to be calibrated.

Absorbency of Paper Towels:

Prerequisites:
simple random sample,
independent sample comparisons of means

Concepts Illustrated:
simple random sample
side-by-side boxplots
checking assumptions
hypothesis test and confidence interval

Each team of 3-4 students has

60 Bounty brand towels
60 store brand towels
20 additional towels
tongs
bucket of water
bowl
stopwatch
scale (unit = 1 gram)

Are Bounty towels more absorbent than store brand?
Teams select simple random samples of 10 Bounty and 10 store brand towels.

Are there simpler ways to take a sample?

Why might these ways not produce a representative sample?

Basic Measurement:

Fold dry towel in fourths
Place dry towel in bowl
and weigh
Grab towel with tongs and
dunk in water for 5 sec.
Remove wet towel and let
it drip for 20 sec.
Place wet towel in bowl
and weigh

Find wet weight - dry weight

Are you finding variability within each brand?

What would cause this variability?

Why is it important to follow the measurement protocol?

Is one brand more absorbent than the other?

Data Analysis:

Students compute descriptive statistics for both samples and construct side-by-side box plots of data.

Is the assumption of normal data reasonable?

Is the assumption of equal variances reasonable?

Students test hypothesis of no mean difference versus alternative than Bounty has a large mean absorbency.

Students compute a confidence interval for the difference in the two means.

Students compute a nonparametric confidence interval for the difference in the two medians.

Students comment on the appropriateness of these analyses based on their conclusions about assumptions.

Teams make oral reports.

Although all teams find that Bounty is better, the confidence intervals differ from team to team.

Student Reaction

Simple random samples are important but not easy.

It is important to follow measurement protocol.

Variation is small relative to the differences in the means.

Bounty is clearly better.

Confidence intervals depend on the sample.

Improving Product Performance:

Prerequisite:
- mean

Concepts Illustrated:
- planned experiment
- two-factor design
- factor selection
- randomization
- main effects
- interaction

Teams of 3-4 students study effects of 2 factors on flight distance of balsa airplane.

What factors could affect flight distance?

Design factors

Launch factors

Weather factors

Can we control these factors?

Our measuring tool is a tape measure.

How do we define flight distance so that we can measure it?

What do we do if a long flight is interrupted by a tree?
Student teams choose 2 levels of 2 factors and control other factors as much as possible.

Teams are creative in choosing factors.

Wing position
Wing size
Tail size
Weight on nose
Launch height
Body shape

Bad weather alternative =

Paper airplanes
Factors = weight of paper, weight on nose, folding design, and launch height.

Four flights are made with each treatment combination.

Flight order is randomized.

Data Analysis:

Students compute descriptive statistics for each treatment combination.

Students prepare side-by-side
dot plots.

Are the means (variances) the same for all treatment combinations?

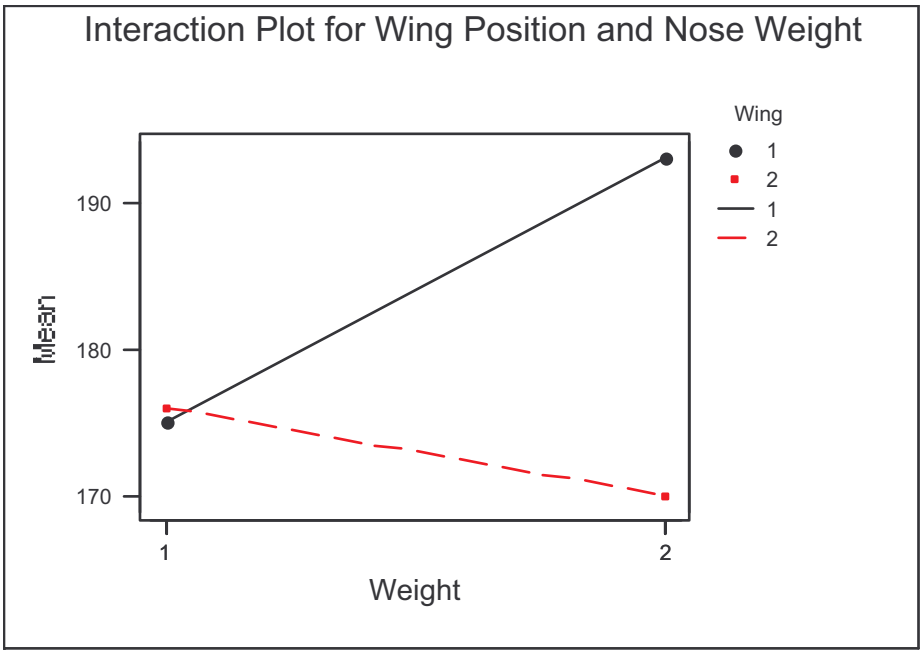
Do you have outliers?

Is one level of the 1st (2nd) factor better than the other?

What treatment combination gives the largest mean?

Does this combination also give the largest variance?

Students make an interaction plot.



What does the plot tell you about the factors and flight distance?

Teams make oral reports.

Some experiments are highly successful and others are not.

Some factors interact and others do not.

One team found factor levels using less wood that doubled flight distance.

What is the impact on the manufacturer?

Student Reaction

Planned experiments can improve products.

There are often many factors.

It is important to randomize.

Not all experiments are successful.

Some factors interact.

Laboratory Manual:

Statistics: Learning by Doing
by John D. Spurrier, Don Edwards, and Lori Thombs

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