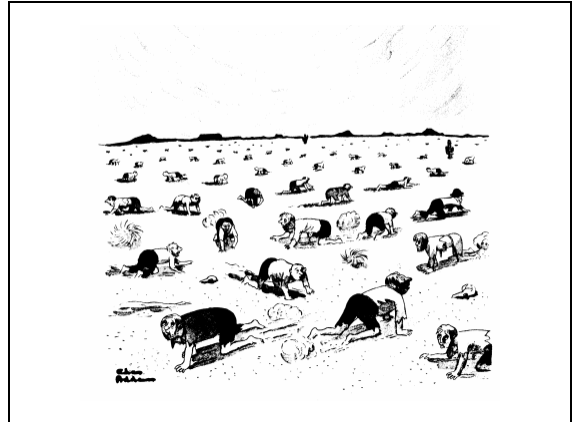


Intro stat should not be like
drinking water through a fire
hose

Kirk Steinhorst
Professor of Statistics
University of Idaho



What is intro stat?

Introductory statistics is ...

The syllabus 30 years ago...

- Descriptive statistics
- Probability
- Sampling distributions
- Hypothesis testing
- Confidence Intervals
- One-way ANOVA
- Simple linear regression
- Chi-square tests

The syllabus today...

- Descriptive statistics
- Study design
- Probability
- Sampling distributions
- Inference in sample surveys—point and interval estimation
- Inference in experiments—and hypothesis testing
- One-way ANOVA
- Simple linear regression
- Chi-square tests (as time allows)

The other addition to the modern intro course is statistical computing.

Descriptive statistics in the old
days

- Measures of location—mean, median, geometric mean, harmonic mean
- Measures of scale—range, variance, standard deviation
- Graphs—relative frequency diagrams and histograms

A great deal of time was spent teaching students how to do the computations.

Descriptive statistics today

- Graphs
 - Quantitative variables—stem-and-leaf plot; dot plot
 - Continuous—histogram, box plot
 - Discrete—bar plot
 - Categorical variables—pie chart, bar plot
 - Statistics
 - Measures of location—mean vs. median and why
 - Measures of scale—range, interquartile range, standard deviation (and variance)
 - Measures of position—percentiles, deciles, quartiles, median
- Note. For categorical variables, we use proportions as the descriptive statistics.

Note:

Resist the temptation to cover two-way frequency tables and scatterplots as part of descriptive statistics. This material is better saved for the chi-square and regression sections later.

Drawing histograms properly

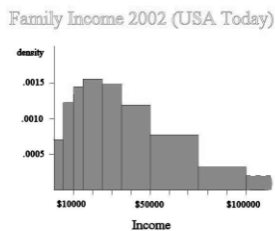
Many modern introductory texts and computer programs confuse frequency graphs, relative frequency graphs, and histograms.

See [histogram video](#)

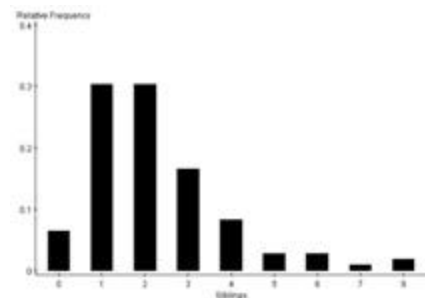
For example...done poorly



And drawn properly...



How does a bar chart differ?



Study design

- Surveys
- Experiments
- Other—observational studies, case studies, random processes, retrospective studies, etc.

Probability in the old days

- Axioms of probability, Venn diagrams, balls and urns
 - General addition rule, complements, conditional probability, independence
 - Permutations/combinations—counting rules
 - Bayes' rule (optional)
 - Binomial and normal distributions
- Note. Many examples involved dice, cards, coins and the like.

The difficulty

- Students found the material hard and boring.
- Students did not see the connection between probability and statistics.
- Students were distracted by the counting rules.

Probability today

The coverage of probability should be closely tied to the subsequent coverage of statistics. The key is to present the basic rules of probability by using probability to describe populations and random sampling from populations.

So what do we do?

We cover the same topics but we use realistic statistical examples.

We introduce probability density and mass functions in general.

See **A New Approach to Learning Probability in the First Statistics Course**

[Journal of Statistics Education, V9N3: Keeler](#)

For example

Current enrollments by college and by sex appear in the following table.

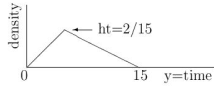
College	Ag-For	Arts-Sci	BusEcon	Educ	Engr	Law	Undecl	Totals
Female	500	1500	400	1000	200	100	800	4500
Male	900	1200	500	500	1300	200	900	5500
Totals	1400	2700	900	1500	1500	300	1700	10000

If I select a student at random, answer the following:

- Find P (Female or Male).
- Find P (not Ag-For).
- Find $P(\text{Female}|\text{BusEcon})$.

...and another example

You are the manager of the complaint department for a large mail order company. Your data and experience indicate that the time it takes to handle a single call has pdf,



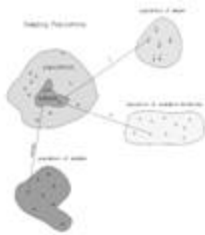
- Show that the area under the triangle is 1.
- Find the probability that a call will take longer than 10 minutes, $P(\text{time} > 10)$.
- Given that the call takes at least 5 minutes, what is the probability that it will take longer than 10 minutes, $P(\text{time} > 10 | \text{time} > 5)$?

Sampling distributions

Most modern texts discuss the asymptotic distribution of sample proportions.

They also discuss the normality of sample means (directly or via the central limit theorem).

I cover the BIGGER ideas...



See [Sampling Distributions](#)
[IntroStatVideos](#)

Students understand...

Knowledgeable statistical readers should be able to decipher
 μ , σ , β , α , σ_{μ} , σ_{β} ,
 β , γ , σ_{γ} , σ_{β} , and σ_{β} .
 All of the symbols have legitimate statistical meanings except
 two which are nonsense.

Of course, we cover

Binomial: $\hat{p} \sim N(p, \sigma_{\hat{p}}^2)$ where $\sigma_{\hat{p}}^2 = \frac{p(1-p)}{n}$

Normal: $\bar{X} \sim N(\mu, \sigma_{\bar{X}}^2)$ where $\sigma_{\bar{X}}^2 = \frac{\sigma^2}{n}$

Survey Inference

Many texts assume that data come from infinite populations under i.i.d. random sampling. Today's student will see analyses of more surveys in their lifetime than anything else.

For this reason, I introduce point and interval estimation with data from sample surveys.

Point estimation

Point estimation follows quite naturally from the previous discussion of descriptive statistics...

$$\hat{\mu} = \bar{X}$$

$$\hat{\pi}_{.5} = \text{the sample median}$$

$$\hat{\sigma} = s$$

etc.

In addition...

We note that the sample histogram is the estimate of the pdf of a continuous random variable and the sample bar graph is the estimate of the pmf of a discrete or categorical random variable.

$\hat{f}(\cdot)$ is the histogram
 $\hat{p}(\cdot)$ is the bar graph

That is why it is important to get these graphs right when you do descriptive statistics.

CIs

One can construct confidence intervals for lots of parameters or differences of parameters.

Restrict the discussion to CIs for single proportions and means. Keep it simple.

I also introduce the fpc—they can handle it 😊

Hypothesis testing

Hypothesis testing has more possibilities for “firehose” teaching behavior.

- Mean or binomial proportion
- z or t
- 1-sample, paired, unpaired
- 1-sided, 2-sided
- Equal or unequal variances

There are at least 22 distinct cases.

Show restraint

- Treat one-sample and paired cases as one.
- Do only t tests for hypotheses involving means.
- In the two-sample, unpaired case, choose either the equal or unequal variance case—I choose equal because it leads to a seamless transition to one-way ANOVA.

One scenario...

- The Z test for a binomial proportion
- The paired t test
- The equal variance unpaired t test

Do both 1- and 2-sided alternatives in each case.

It is a matter of personal choice whether you test means first or proportions.

One-way ANOVA

- The idea
- Side-by-side box plots
- The AOV table
- The F and p-values and their interpretation.

Simple linear regression

- Scatterplots
- Review the equation of a line
- Point and interval estimation (use “The Figure”)
- Test of zero slope
- Calculation and interpretation of correlation

Chi-square tests (as time allows)

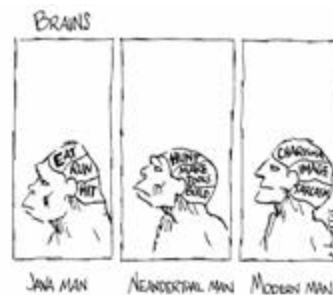
- Find a good example of a one-way table of counts. Illustrate the computation of expected values.
- Compute the Pearson chi-square formula for this example.
- If time permits do a two-way table.

Schedule

Intro and descriptive statistics (or study design).....	1 week
Study design (or descriptive statistics).....	1 week
Probability using the population approach.....	3 weeks
Sampling distributions in general.....	1 week
Survey inference.....	2 weeks
Experiments and hypothesis testing.....	2 weeks
One-way ANOVA.....	1 week
Simple linear regression.....	2 weeks
Chi-square tests (as time allows).....	1 week
Tests.....	1 week
Total.....	15 weeks



"We have reasons for believing that this number is the most important number known."



Testing and assessing in a modern statistics methods course

Kirk Steinhurst
Professor of Statistics
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In the beginning...

- Lecture
- Homework
- Tests

We had to teach a lot of mechanics ...and thus we tested a lot of mechanics.

Now...

- Minilectures
- In-class activities
- Homework
- Tests

Assessment has changed because of changes in philosophy and technology.

Changed philosophy

- Authentic assessment
- Departure from traditional lecturing
- Change from teaching mechanics to analyzing real data sets to teaching statistical reasoning (as well)

New technology

Ubiquitous computing has removed the burden of arithmetic...so after hand calculating a small example or two...

At the present time, most students have access to a computer where they live or in campus labs.

Some students have laptops and some campuses provide wireless connectivity.

In the not so distant future students will carry computing

Assessment

- In-class activities keep the students focused and they help me keep track of what the students are learning and where more effort is needed.
- Homework is still important.
- I use 2 or 3 specially organized hourly tests and a comprehensive final.

In-class activities

I use in-class activities as a learning tool and for assessment

Students work in small groups after the minilecture.

The activities replace the rest of the traditional lecture providing opportunities for experiential learning.

These activities are usually done in groups. This encourages “students learning from students” and makes the grading easier.

I do not manage groups, but perhaps I should.

Some students are not prepared to do an activity on material just covered in the minilecture.

For example...

Given...



Activity 18

The groups are asked to verify that the standard error is 0.1 by giving the formula and working through the numbers.

They have about 20 minutes to complete this activity.

Conceptual activity

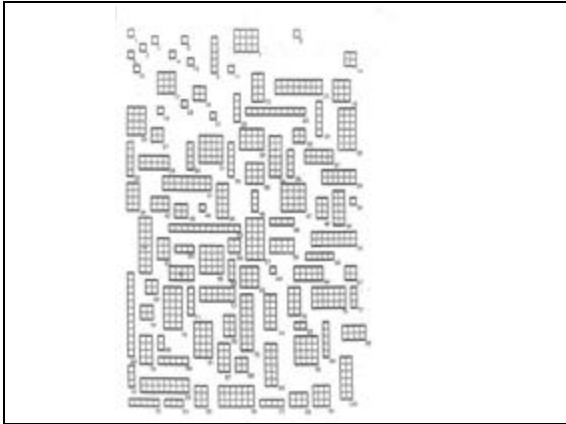
Consider the snow depth data set.

- 1) What type of study is it?
What is the population?
What is the () unit?*
- 2) Discuss where appropriate—
Frame, double blind, response
variable, method of randomization.*

Concrete activity

I usually do the “random rectangles” activity from the Scheaffer et al. book. I give them the rectangle drawing and tell them that the figures represent the numbers of potential customers around the campus for a new bike repair service they and a friend are about to startup.

I first ask them to make an “ocular” estimate of the total number of potential customers.



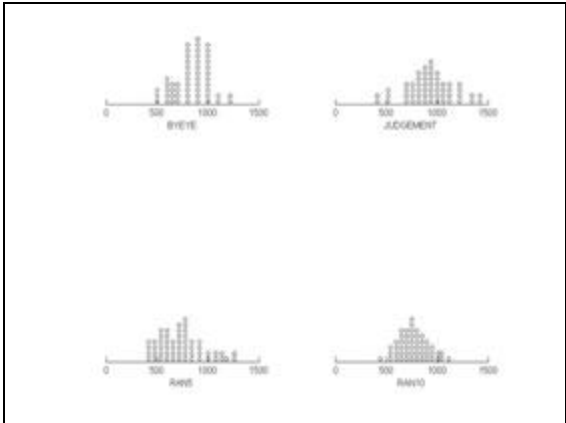
I then ask them to pick 5 “representative” living units and compute the average and multiply it by 100 thus producing an estimate of the total.

I next have them pick 5 two digit numbers from a random number table and use them to select 5 living groups at random. They compute the average of these and multiply by 100.

We repeat the random selection with 10 random numbers.

At each stage, I build a dot plot of the results on the board. In almost every case, the estimates get better as we go. Students are convinced that random sampling works.

Students turn the answers in for activity credit and I enter all the data into a computer package and produce graphical and tabular summaries which I present at the next class meeting.



Homework

Homework?

Just assign homework, but don't grade it?

Assign and grade homework

CyberStats or iLrn or ...

Homework can be mostly mechanical...

A. Refer to Example 11.4 of the chapter where for a sample of $n = 100$ national adults, $\bar{x} = 97$ was the proportion that think the economy is better. Compute a 95% confidence interval for the population proportion. $\bar{x} = \dots \dots \dots$

B. A confidence interval sample of $n = 12$ students is currently in hand. How much did you spend for textbooks this semester? The responses in dollars are:
200 110 400 300 100 200 100 200 100 400 200

C. Compute a confidence interval for the population mean.

Sample	n	Mean	SD	95% CI	99% CI
1	10	20.4	4.1	(17.2, 23.6)	(14.8, 26.0)

D. Find the 95% confidence interval for the true mean.

Or conceptual...



Questions

Semi automated computer-based homework systems provide a feasible way to assign and grade homework in large classes.

Should the students have a limited number of tries?
Should students be able to see help notes after X tries?
How about algorithmic homework systems?

Testing

Testing presents one of the greatest challenges in the current course climate. How can it be authentic? What about technology? Can students use any calculator or computing device? How do you test concepts?

My solution

Over the last 10 years I have developed a solution that addresses most of these issues—I call it the takehome/in-class test system.

Students are given a takehome exam on Monday (say) and on Friday they bring the takehome exam to class and use it to answer the in-class exam.

They do not turn in the takehome exam.

Benefits

- Students can use computer resources when preparing the takehome answers.
- Students can work together on the takehome.
- The takehome removes some of the fear associated with statistics exams.
- Students are individually responsible for knowing the material.



Do better at...

- Working problems out in detail by hand—not CyberStats XXXXXXXXXXXXXXXX
- \int ing XXXXXXXXXXXXXXXX
Especially technical difficulties
- Explaining equations and symbols XXXXXXXXXXXXXXXX
- Helping us understand the material XXXXXX
- Figuring out how to use CyberStats and/or \int ing XXXXXXXXXXXXXXXX
- \int ing XXXXXXXX
- Too much new material, too fast XXXXX
- Handwriting XXXX
- Text review, add review sessions
- Talk about homework after it is due XXX
- Text XX
- Limit time on homework to counteract “guessing” XXXX
- Make homework exactly like the book
- Handing back assignments
- Class discussion
- T.A.
- More review and repetition
- More S.A.C. time

In summary

- In-class activities (100 points using best 70%)
- Homework (100 points)
- “Progressive supper” tests (3x100 + 150 points)
Total is 650 points.
- Course evaluations



"LIFE IS ONE IN A HUNDRED, MY DEAR BOSS! SOMETHING IS!"