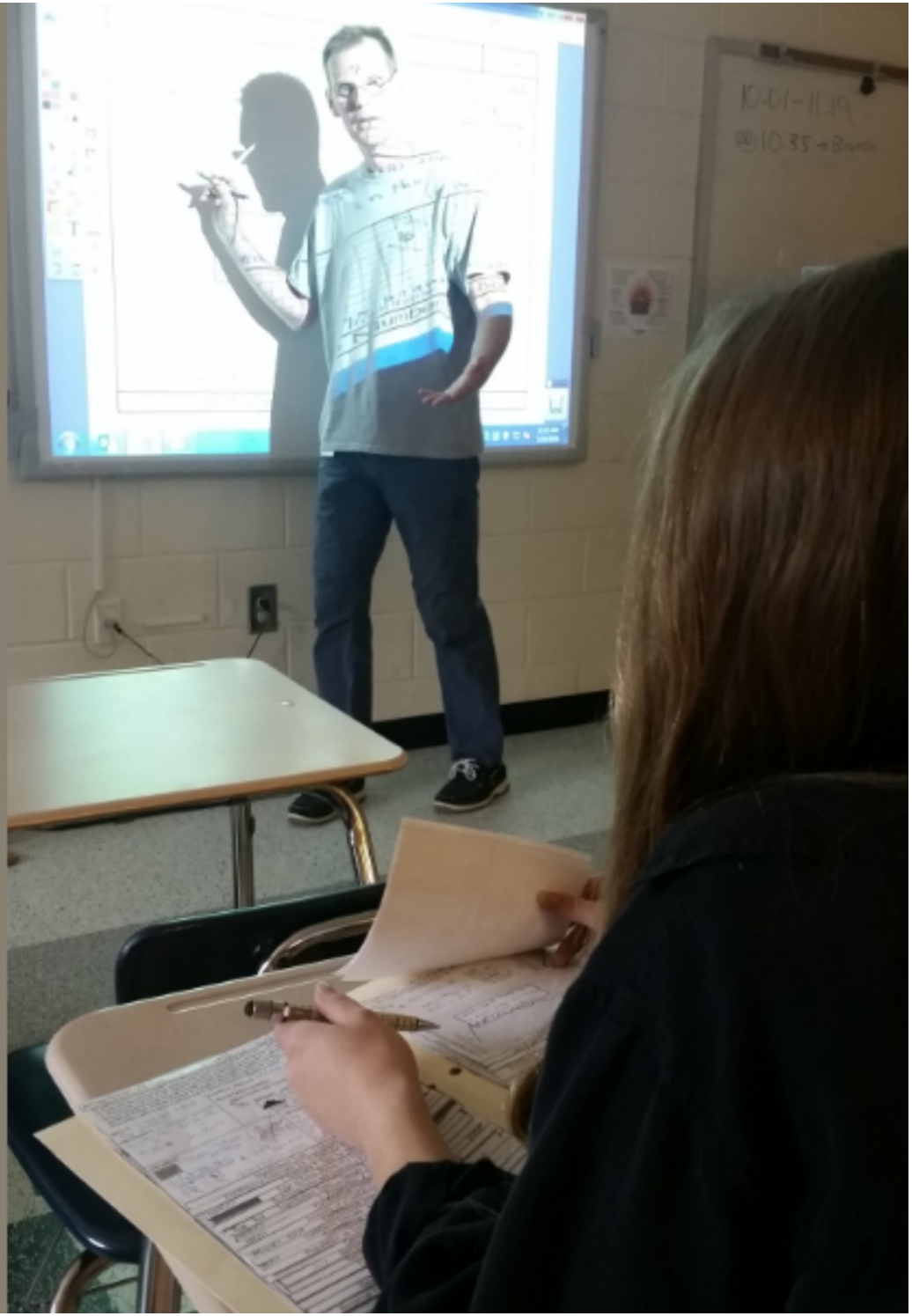
There's something about a fill - in - the - _____!

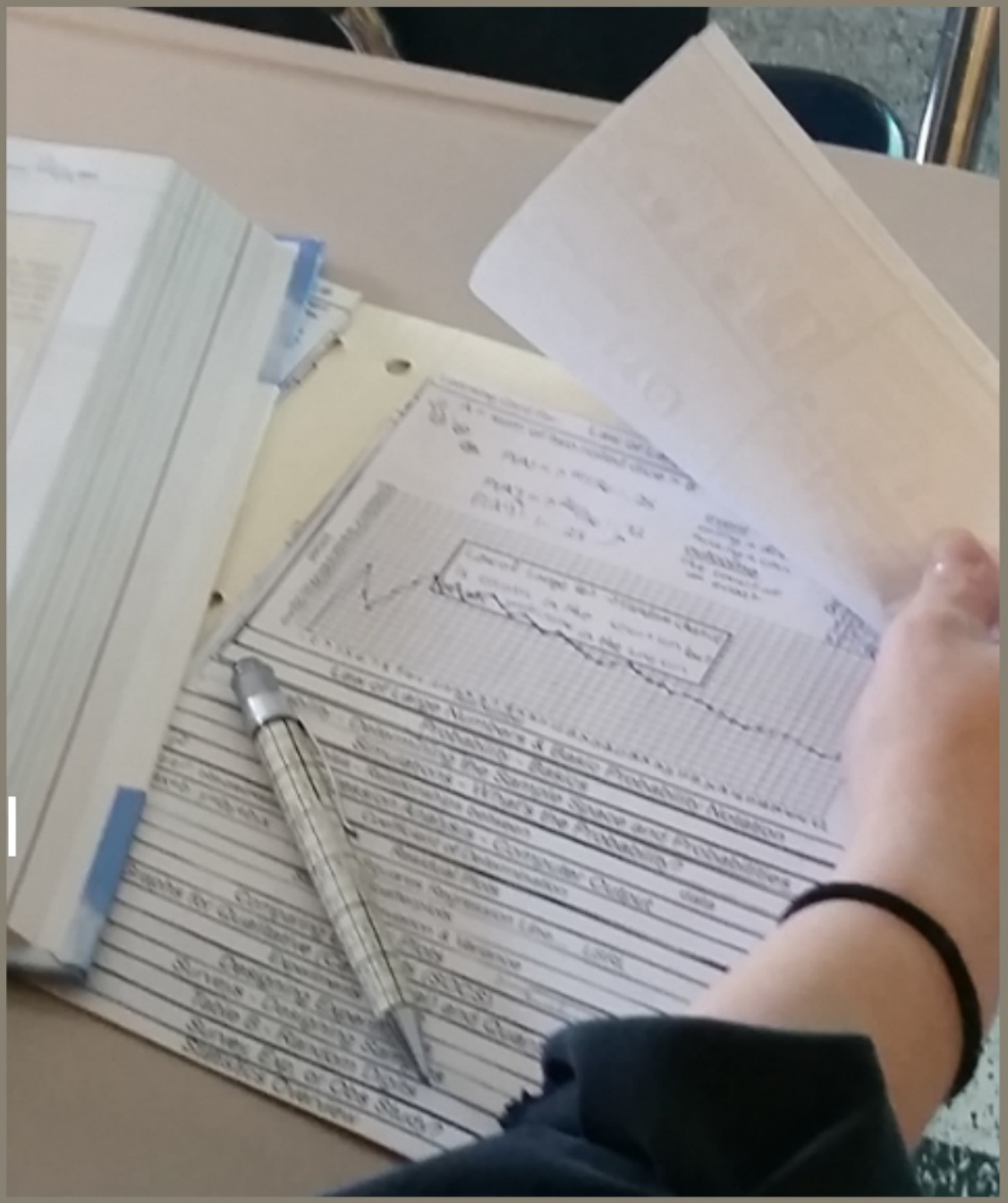
There's something about a fill - in - the - _____ !

Blank

That's the idea behind the learning cards designed specifically for AP Statistics...



- structure to note taking
- reference for...
  - homework
  - classwork
  - unit tests, midterm & final
  - AP Exam
  - future courses



Learning Card for Survey, Exp, or Obs Study?	Name	Card #

Opinion

Best for _____

Need to select participants _____ to avoid _____ in the results. We want a good _____ of the whole population.

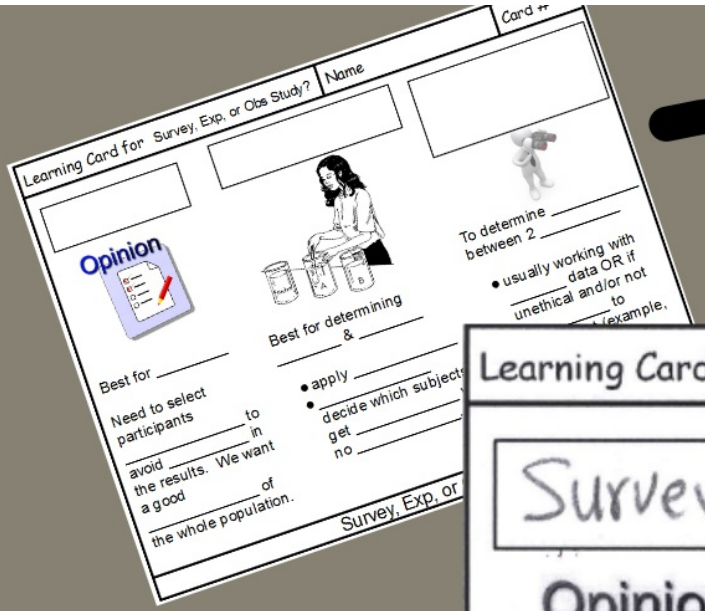
Best for determining _____ & _____

- apply _____
- _____ decide which subjects get _____ vs. no _____.

To determine _____ between 2 _____

- usually working with _____ data OR if unethical and/or not _____ to experiment (example, smoking studies)
- no _____ with participants... _____ only!

Survey, Exp, or Obs Study?



Learning Card for Survey, Exp, or Obs Study? | Name Key | Card # 1

Surveys

Best for opinions

Need to select participants randomly to avoid bias in the results. We want a good representation of the whole population.

Experiments

Best for determining cause & effect

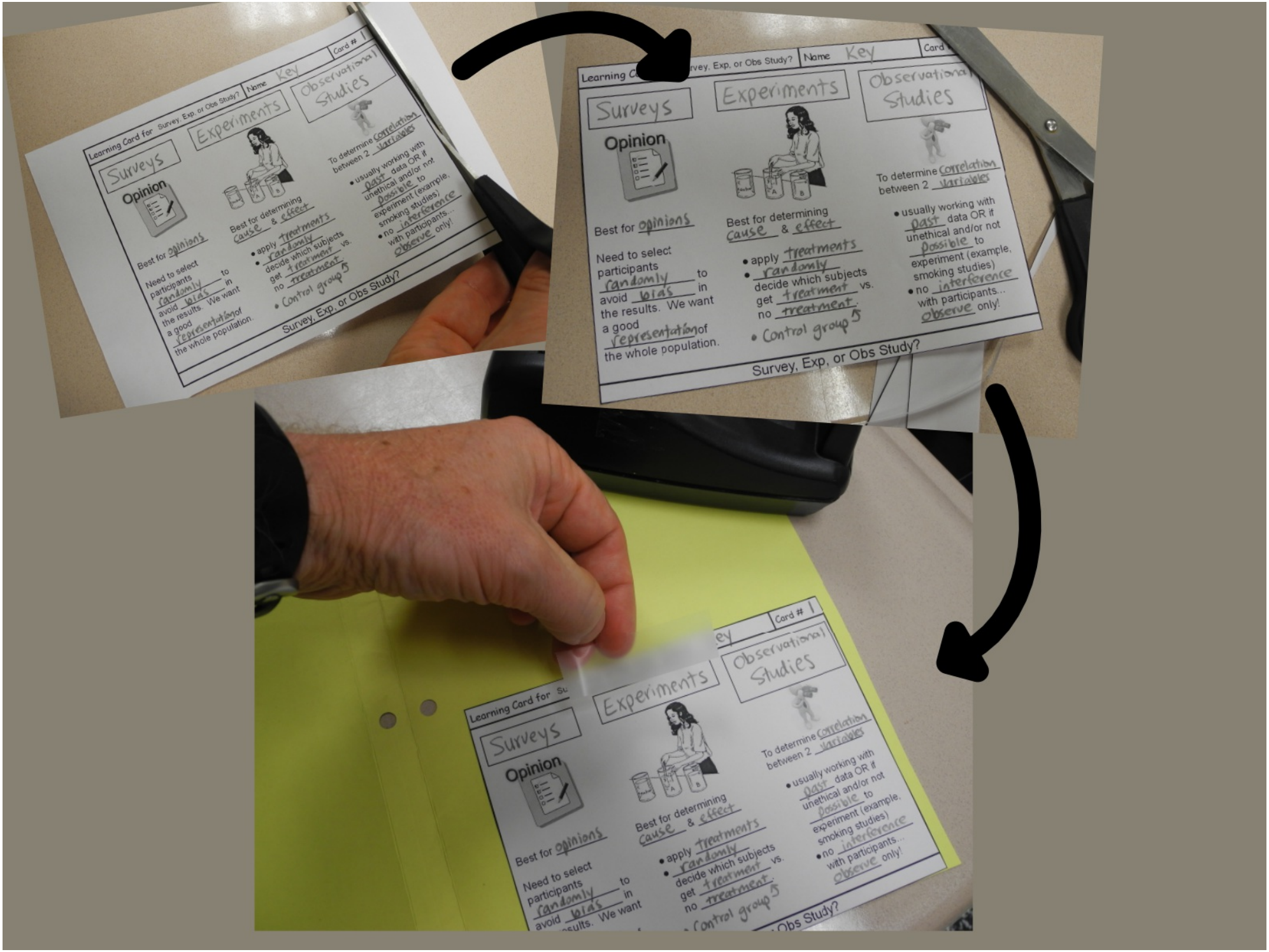
- apply treatments
- randomly decide which subjects get treatment vs. no treatment.
- Control group 5

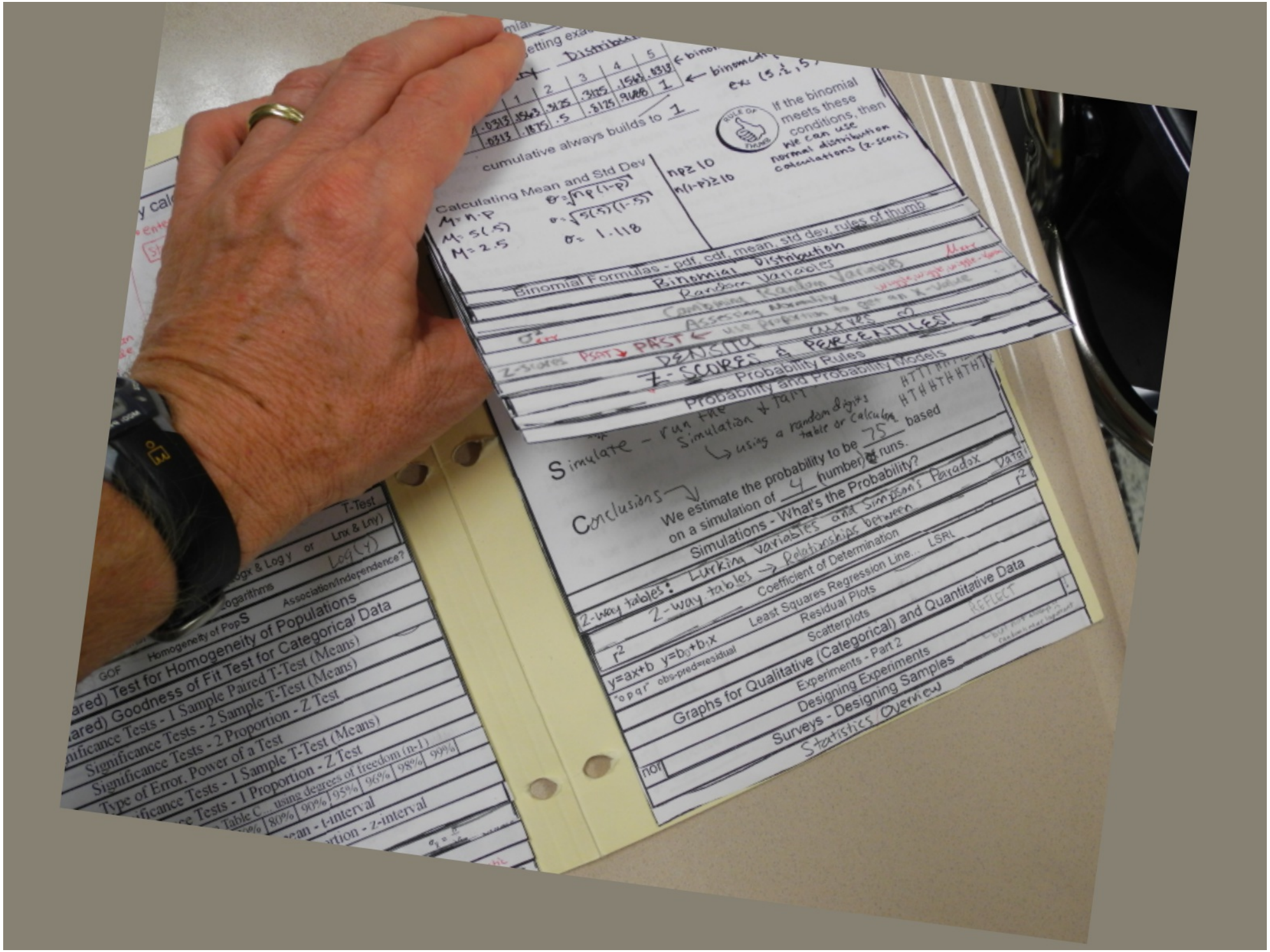
Observational Studies

To determine correlation between 2 variables

- usually working with past data OR if unethical and/or not possible to experiment (example, smoking studies)
- no interference with participants... observe only!

Survey, Exp, or Obs Study?


Learning Card for Survey, Exp, or Obs Study?
Name Key
Card # 1
Surveys
Opinion
Best for opinions
Need to select participants randomly to avoid bias in the results. We want a good representation of the whole population.
Experiments
Best for determining Cause & effect
• apply treatments
• randomly decide which subjects get treatment vs. no treatment.
• Control group
Observational Studies
To determine correlation between 2 variables
• usually working with past data OR if unethical and/or not possible to experiment (example, smoking studies)
• no interference with participants... observe only!
Survey, Exp, or Obs Study?


Calculating Mean and Std Dev
Binomial Formulas - pdf, cdf, mean, std dev, rules of thumb
Binomial Distribution
Random Variables
Probability Rules
Probability and Probability Models
Simulate - run the
Conclusions
We estimate the probability to be
on a simulation of
Simulations - What's the Probability?
2-way tables: Lurking Variables
2-way tables → Relationships between
Coefficient of Determination
Least Squares Regression Line... LSRL
Residual Plots
Scatterplots
Graphs for Qualitative (Categorical) and Quantitative Data
Experiments - Part 2
Designing Experiments
Surveys - Designing Samples
Statistics Overview
T-Test
Goodness of Fit Test for Categorical Data
Significance Tests - 1 Sample Paired T-Test (Means)
Significance Tests - 2 Sample T-Test (Means)
Significance Tests - 2 Proportion - Z Test
Type of Error, Power of a Test
Significance Tests - 1 Sample T-Test (Means)
Significance Tests - 1 Proportion - Z Test

order	Unit of Study	Learning Card Name
1	Introduction	statistics overview
2	Designing Studies	survey experiment or obs stud
3	Designing Studies	random digits table
4	Designing Studies	surveys – designing samples
5	Designing Studies	designing experiments
6	Designing Studies	experiments – part 2
7	Analyzing Data	graphs for qualitative and qua
8	Analyzing Data	comparing data sets (SOCS)
9	Analyzing Data	box plots
10	Analyzing Data	standard deviation
11	Analyzing Data	transforming data
12	Bivariate Data	scatterplots
13	Bivariate Data	least squares regression lines
14	Bivariate Data	residual plots
15	Bivariate Data	coefficient of determination
16	Bivariate Data	regression analysis – compute
17	Bivariate Data	2 way tables – categorical data
18	Probability	simulation
19	Probability	probability – determining the
20	Probability	probability – basics
21	Probability	law of large numbers
22	Probability	compound probabilities
23	Probability	conditional probabilities
24	Probability	venn diagrams
25	Random Variables	building a normal distribution
26	Random Variables	z-scores and normally distribu
27	Random Variables	z-scores and normally distribu
28	Random Variables	random variables – continuou
29	Random Variables	discrete – binomial settings
30	Random Variables	discrete – more on binomial settings
31	Random Variables	discrete – geometric settings
32	Random Variables	combining random variables
33	Sampling Distributions	sampling distributions – proportio
34	Sampling Distributions	sampling distributions – means
35	Sampling Distributions	central limit theorem – for means
36	Sampling Distributions	sampling distributions – bias and
37	Confidence Intervals	confidence intervals – anatomy o
38	Confidence Intervals	confidence intervals – proportion
39	Confidence Intervals	confidence intervals–means–sig
40	Confidence intervals	confidence intervals–means–sig
41	Confidence intervals	confidence intervals – reducing
42	1 sample tests	1 proportion z-test
43	1 sample tests	1 sample t-test for means
44	1 sample tests	1 sample t-test for means – pair
45	1 sample tests	error types, power of a test
46	1 sample tests	reducing error and increasing p
47	2 sample tests	2 sample t-test for means
48	2 sample tests	2 sample confidence interval vs
49	2 sample tests	2 sample z-test for proportions
50	2 sample tests	2 samp conf int vs 2 prop z tes
51	Chi Square tests	chi square – goodness of fit te
52	Chi Square tests	chi square – homogeneity of p
53	Chi Square tests	chi square – association/indep
54	Regression inference	linear regression inference
55	Regression inference	transformations – power
56	Regression inference	transformations – exponentia
57	Regression inference	transforming linear eqtns – p
58	Regression inference	linear regression – confidenc

Table of Contents – Learning Cards for AP Statistics

Mark Fisher
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original order	Unit of Study	Learning Card N…	flipcharts	blank pdfs	filled out pdfs	iwb format	teacher notes
1	Introduction						

Learning Card for Designing Experiments

Name

Card #

Purpose of an experiment -

Control

Control Group

Placebo effect

Replication

Randomization

Experimental Units

Factors

(

)

Levels

Treatment

Designing Experiments

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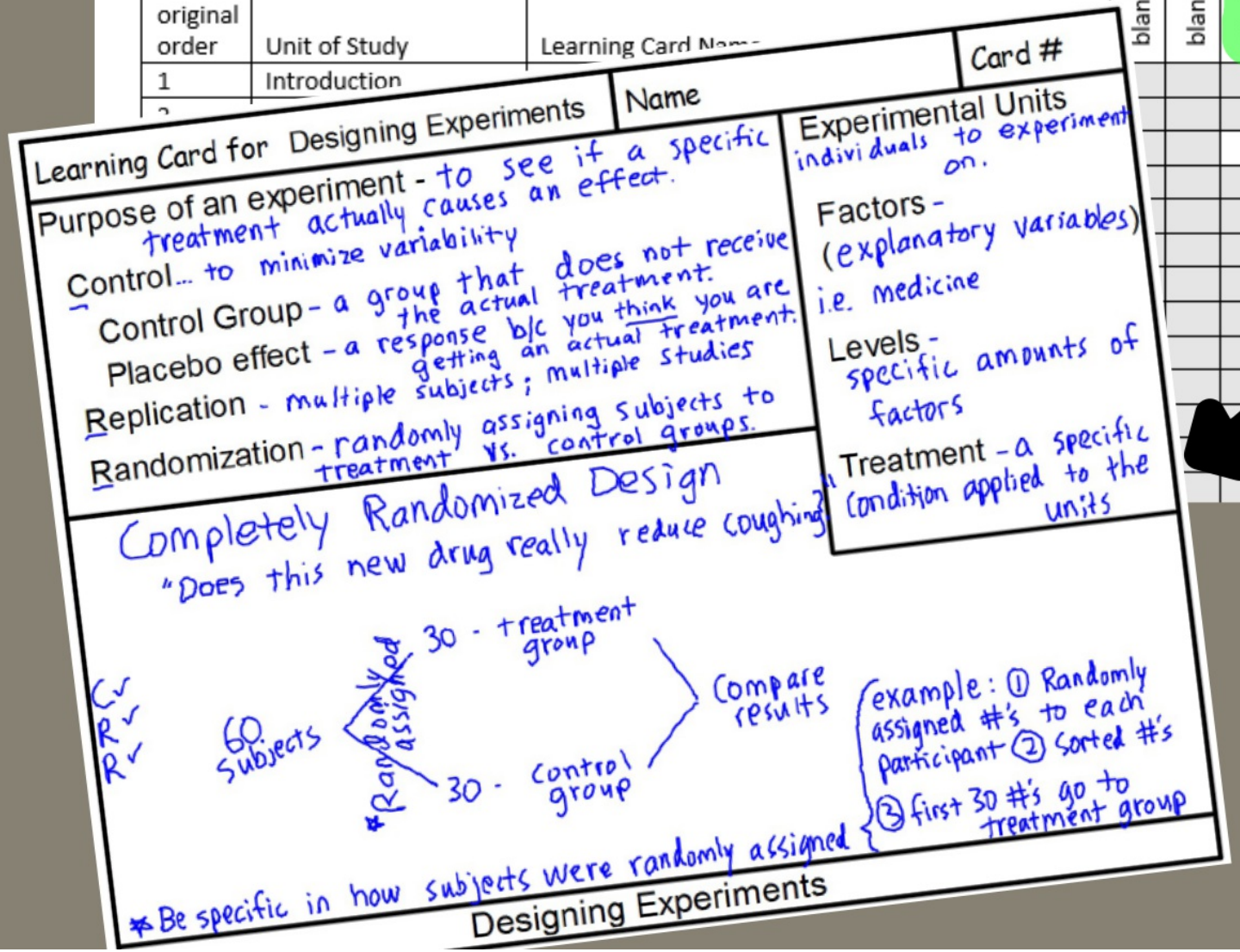

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1	Introd...						

Used results from the discrimination simulation activity for hiring pilots (male vs. female). Could use any simulation to see how variability naturally occurs based on random chance.

Learning Card for Statistics Overview

Name

Card #

Use Probability...

Was there discrimination?

OR could this result just be due to random chance?

0 1 2 3 4 5 6 7 8
females chosen

Infer upon the population...

if my sample shows tall people,
then the true population
is likely to
have tall people

"inference"

Probability

Inference

Data Production

Data Analysis

Analyze Data...

Who are the individuals described?
What variables?

Why was the data collected?
Where " " " "
When " " " "
How " " " "
by Whom " " " "

Gather Data...

from existing sources... internet, previous studies, etc.

OR Produce it

- Surveys → opinions
- Observational studies → no interference → associations
- Experiments → apply treatments → cause and effect

Statistics Overview

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2	Designing Studies	survey experim...					
3	Designing Studi...						

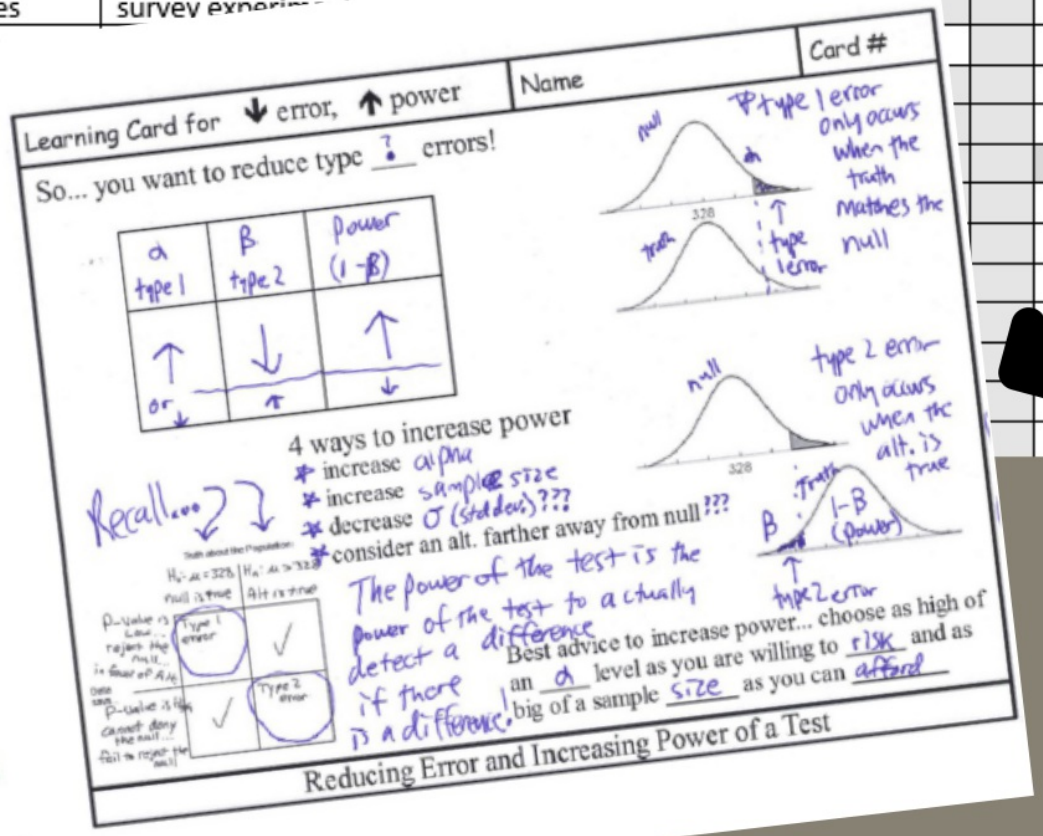
npr

handwashing study - audio file - play this audio clip to emphasize the need to evaluate consequences of type 1 and type 2 errors.

stop at 1:43 and talk about research methods... experiment, obs study or survey? Why don't they do a survey?

continue audio to see which type of study it is

stop at 2:30... why so big? who pays for this study? why is the issue so important? lives at stake, billions of dollars in medical costs... which error type do you try harder to reduce?



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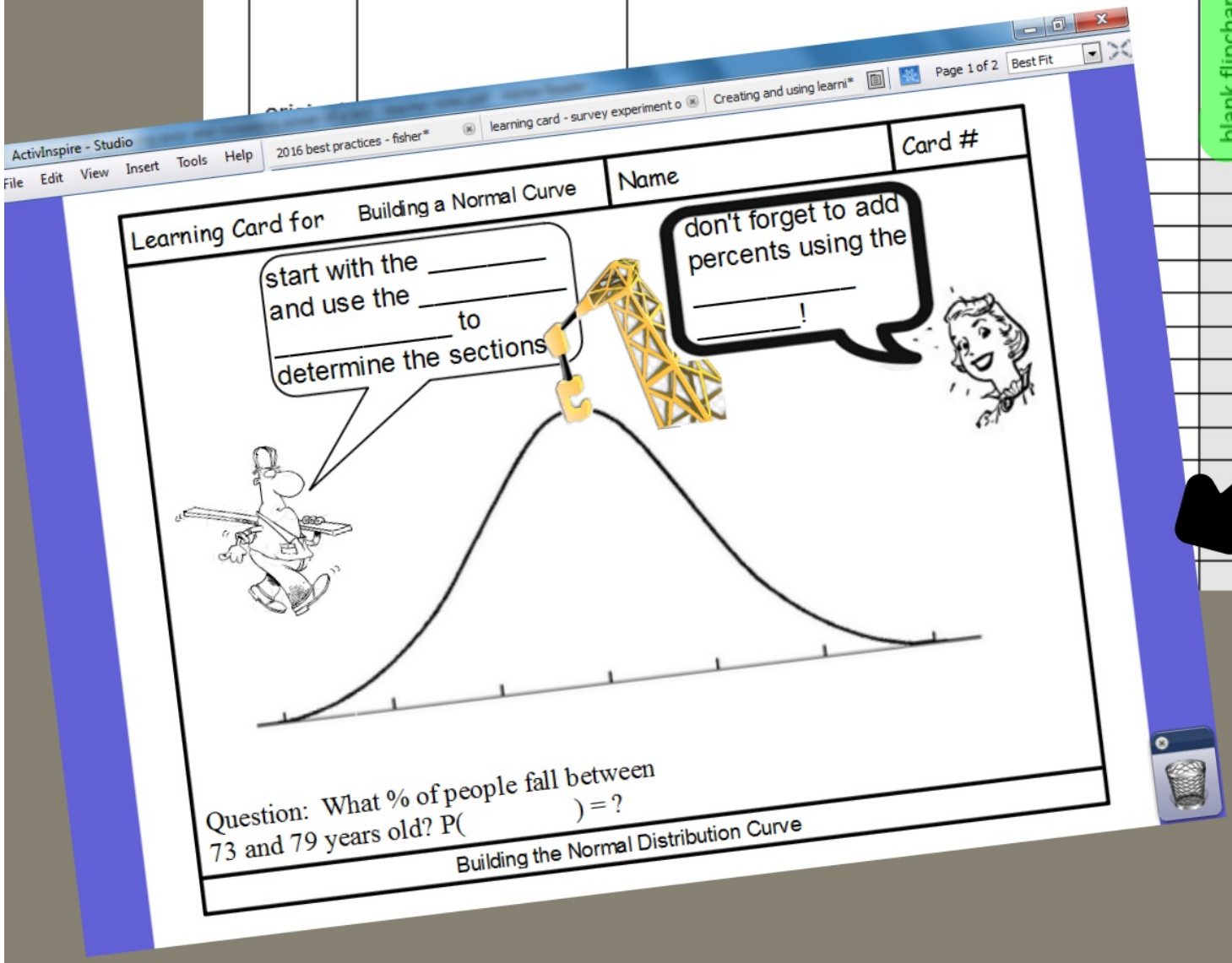

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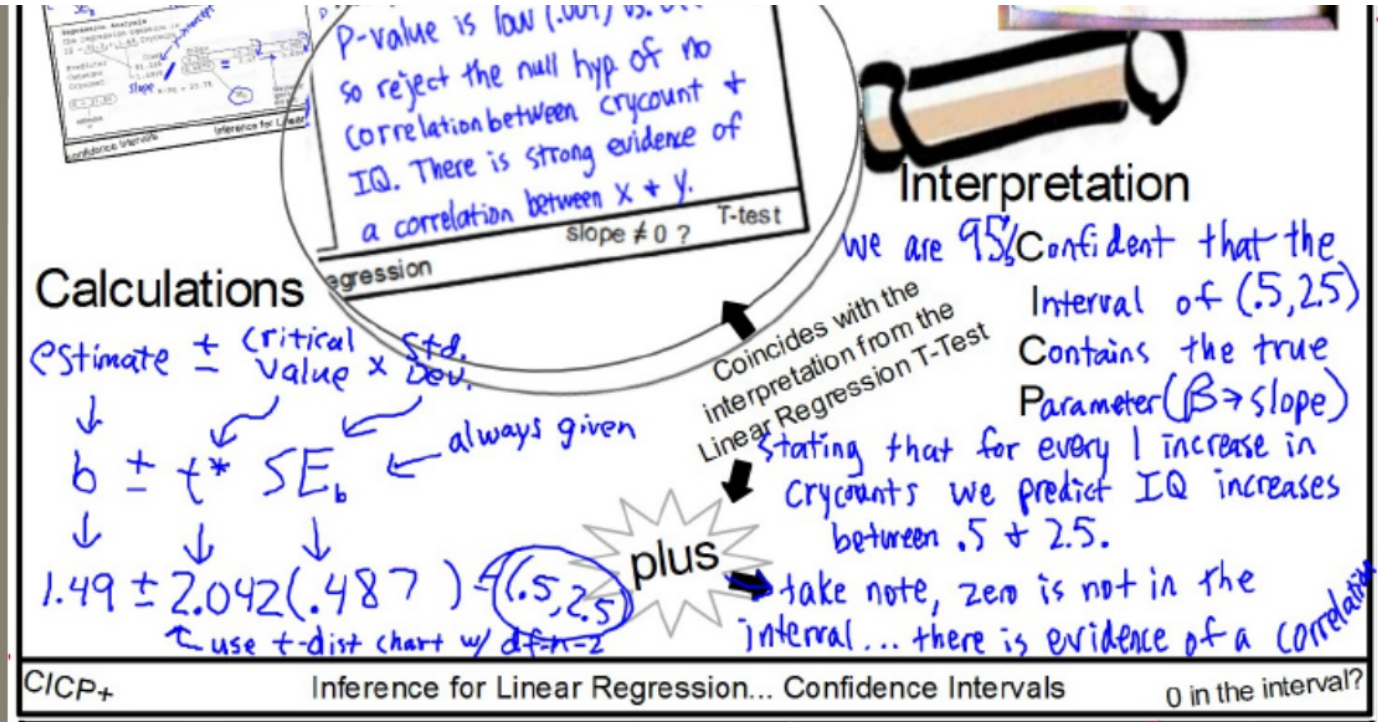
6	Designing Studies	experiments – part 2					
7	Analyzing Data	graphs for qualitative					
8	Analyzing Data						
9	An						
10	An						
11	An						
12	Biv						
13	Biv						

iwb... "interactive white board"

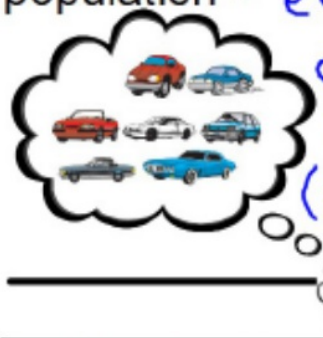
For import into Smart Board and other interactive white board programs.



CICP+	Inference for Linear Regression... Confidence Intervals	0 in the interval?
	χ^2 (Chi Squared) Test for Homogeneity of Populations	
	Significance Tests - 2 Sample T-Test (Means)	
NiHiCCI	1 Sample T Test for Means	σ unknown
NiCCI...CICP	Confidence Intervals - Mean	σ known
	Central Limit Theorem	
	Binomial Setting	
	Z-scores and Normally Distributed Data	
	Probability - Determining the Sample Space and Probabilities	
	Simulations - What's the Probability?	
y=ax+b y=b_0+b_1x	Least Squares Regression Line... LSRL	
	Comparing Data Sets (SOCS)	
	Surveys - Designing Samples	

Learning Card for Sampling Techniques	Name	Card #

population - everybody



census

or sample (portion of the group)

Voluntary Response - individuals choose to respond - usually biased towards strong, negative opinions.

Convenience - Survey those who are easy to reach, can be biased.

Probability Samples

groups must be representative of population

SRS (Simple Random Sample)

- names-in-a-hat
- everyone has equal chance
- every group of size n has equal chance

Stratified

1. Divide population into groups based on an important characteristic
2. Select a proportional SRS from each group or Strata

Cluster

1. Utilize existing groups or clusters that are easy to access.
2. Randomly select groups
3. Survey everyone in the selected groups.

Systematic

1. Randomly choose a starting point
2. choose every n^{th} person after that.

Cautions!

Response Bias - bias due to how you ask the question

undercoverage - groups left out of your selection pool.

nonresponse - bias b/c some refuse to participate or can't be contacted.

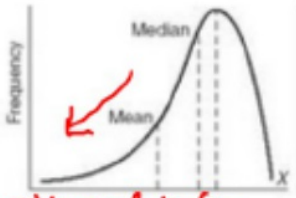
Inference to the Population

↳ getting good samples allows you to give accurate estimates of the overall population.

Surveys - Designing Samples

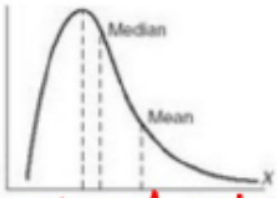
Learning Card for Comparing Data Sets	Name	Card #

Shape

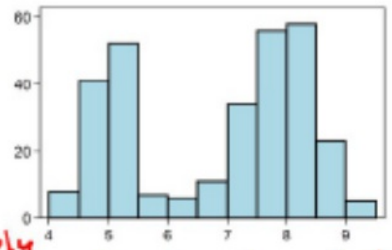


- skewed left
- negatively skewed

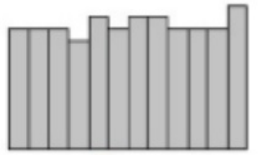
- unimodal
- symmetrical



- skewed positively or right
- unimodal

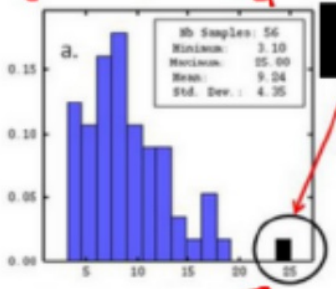


2 peaks = bimodal

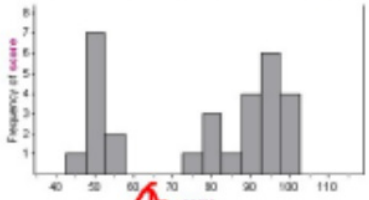


- uniform

Outliers (& unusual features)



1 outlier



a major gap in the data

Center	Spread
if symmetrical... use → mean	+ std. deviation
if heavily skewed... use → median	+ IQR / Range

Comparing Data Sets (SOCS)

nonresponse - bias b/c some refuse to participate or can't be contacted.

accurate estimates of the overall population.

Surveys - Designing Samples

Learning Card for	Least Squares Regression Line	Name	Card #

What is it?

The Line that best represents the linear relationship between 2 quantitative variables.

The line minimizes the residuals

O P ^eQuals R

observed − predicted = residual

How do I calculate it?

items needed: $\bar{x} = 62.4$ $S_x = 31.9$

$\bar{y} = 5.1$ $S_y = 4.2$

$r = -.87$

① Calc slope $b_1 = r\frac{S_y}{S_x}$

$b_1 = -.87\left(\frac{4.2}{31.9}\right) = -.115$

② Calc. y-intercept

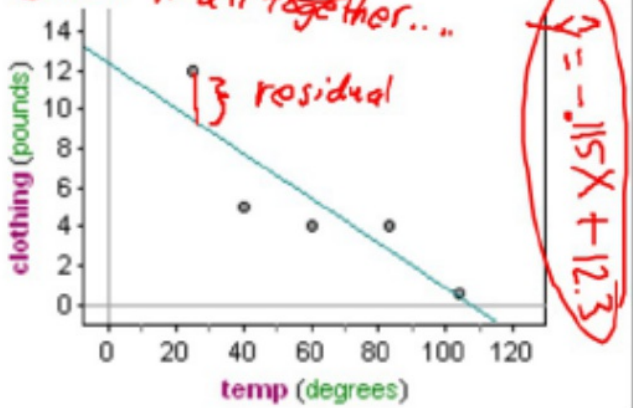
$b_0 = \bar{y} - b_1\bar{x}$

$b_0 = 5.1 - (-.115)(62.4)$

$b_0 = 12.3$

③ Put it all together...

temp	clothing
degrees	pounds
25 deg	12.0 lb
40 deg	5.0 lb
60 deg	4.0 lb
83 deg	4.0 lb
104 deg	0.5 lb



How do I use it?

to interpret slope...

For every increase of (x) 1 degree in temp.

we predict that (y) pounds of clothing will decrease by .115

to interpret y-int...

If zero degrees

then the pounds of clothing is predicted to be 12.3

to make predictions...

if temp is 50°, then...

$\hat{y} = -.115(50) + 12.3$

$\hat{y} = 6.6$

$y = ax + b$ $y = b_0 + b_1x$ Least Squares Regression Line... LSRL

undercoverage - groups left out of your selection pool.

nonresponse - bias b/c groups left out or can't be contacted.

accurate estimates of the overall population.

Comparing Data Sets (SOCS)

Surveys - Designing Samples

Learning Card for Simulation	Name	Card #

Simulation... an *imitation* of chance behavior usually carried out with *random* numbers.

State the problem or *question* at hand

Independent events? Other assumptions? *equal chances, etc.?*

Map digit assignments
state what each digit represents

Simulate
run the simulation & tally the results

Conclude by *answering* the original question given your simulation results

example:

3-way tie to be broken with coin flips. Each team tosses a coin. "Odd man out" meant that whichever team's result was different, that team is out. When all coins come up the same result, TV reporters seem amazed that this happens. What's the probability that all 3 coins come up the same? All heads or all tails?

State

Ind? Coin tosses are independent of each other; fair coins.

Map 0-4 = Heads, 5-9 = Tails or (even = heads, odd = tails)

Simulate - using random digits table starting @ Line 101, ran 30 sets of 3 coin tosses →

same	diffn't
𝍸 𝍸	𝍸 𝍸
𝍸 𝍸	𝍸 𝍸
(10)	(20)

Conclude - Coins came up the same one-third of the time... not that unusual

Simulations - What's the Probability?

Comparing Data Sets (SOCS)

Surveys - Designing Samples

Learning Card for Sample Space	Name	Card #

To determine the sample space...

Make a random list

1,1 5,5 2,4

a systematic listing

1,1	2,1	3,1
1,2	2,2	3,2
1,3	⋮	⋮
⋮		

2-way table (for 2 events)

Die #1

Die #2	1	2	3	4	5	6
1	2	3	4	5	6	7
2	3	4	5	6	7	8
3	4	5	6	7	8	9
4	5	6	7	8	9	10
5	6	7	8	9	10	11
6	7	8	9	10	11	12

Good for "What are the combos"

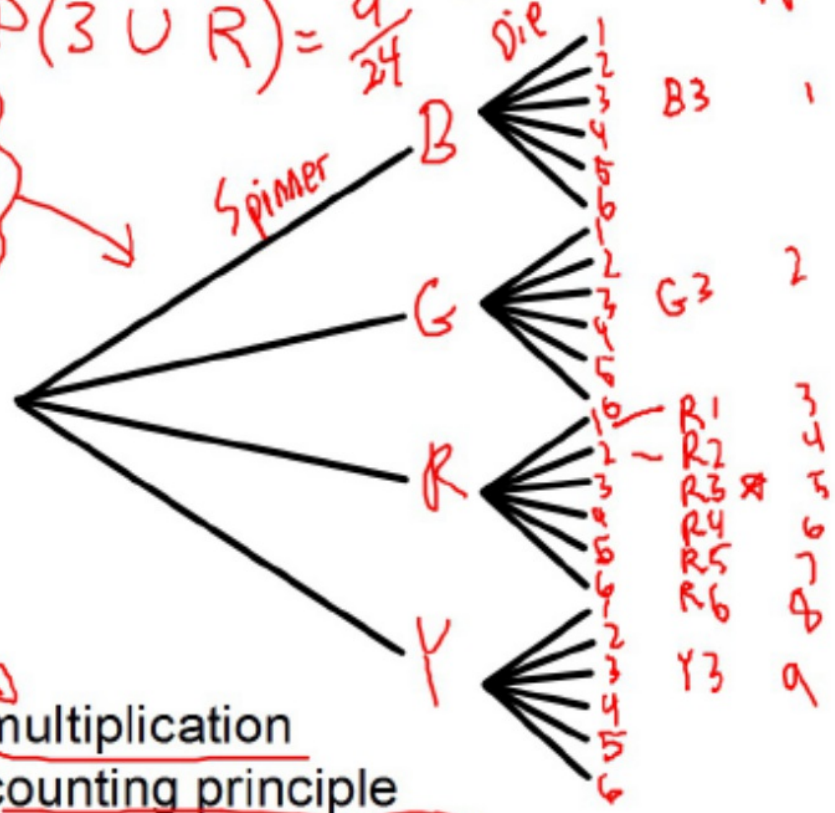
Good for "How many" Questions

roll the die and

spin the spinner

tree diagram

$P(3 \cup R) = \frac{9}{24}$



multiplication counting principle

$4 \times 6 = 24$

Probability - Determining the Sample Space and Probabilities

Comparing Data Sets (SOCS)

Surveys - Designing Samples

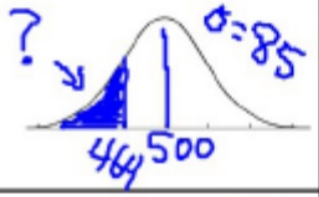
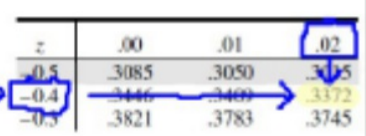
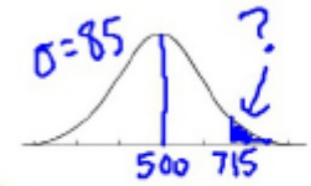
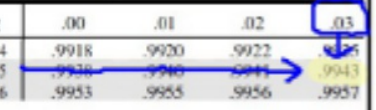
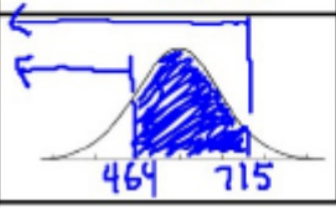
Learning Card for Z-scores and Normal Dist.	Name	Card #

If... NORMALLY distributed

PSAT scores are normally distributed with a mean (μ) of 500 and a standard deviation (σ) of 85

μ = population mean

σ = population std. dev.

	Picture (Draw a)	**S**tandardiZe	**A**SK the table or calculator	**T**ell answer in context
What proportion of students scored below 464?		$z = \frac{x-\mu}{\sigma} = \frac{464-500}{85}$ $z = -.42$		33.72% of students scored below 464
What proportion of students scored above 715?		$z = \frac{x-\mu}{\sigma} = \frac{715-500}{85}$ $= 2.53$	$1 - .9943 = .0057$ 	.57% of students scored above 715.
What proportion of students scored between 464&715?		715 → .9943 464 → .3372 .6571	use info from tables above or normalcdf(-.42,2.53,0,1) normalcdf(464,715,500,85)	65.71% of students scored between 464 & 715.

Z-scores and Normally Distributed Data

(Comparing Data Sets (SOCS))

Surveys - Designing Samples

Learning Card for Binomial Dist | Name | Card #

How do I determine if it is a Binomial Setting?

It's a...

Success/Failure — each observation results in success or failure

N-observations - a fixed #of trials

All are independent

Probability of success for each trial has to be equal

B(n,p) B(7,.5)

Binomial Distribution with n observations where each has the probability, p for Success.

Binomial Formula

$$P(X=K) = \binom{n}{k} p^{k} (1-p)^{n-k}$$

- #of successes
- #of trials
- Probability of failure
- #of failures
- Probability of success

Use Calculator to get the number of combinations of 6 successes from 7 trials... enter this... 7, math, prb, nCr, enter, 6, enter

$$P(x=6) = \binom{7}{6} .5^{6} (1-.5)^{7-6}$$

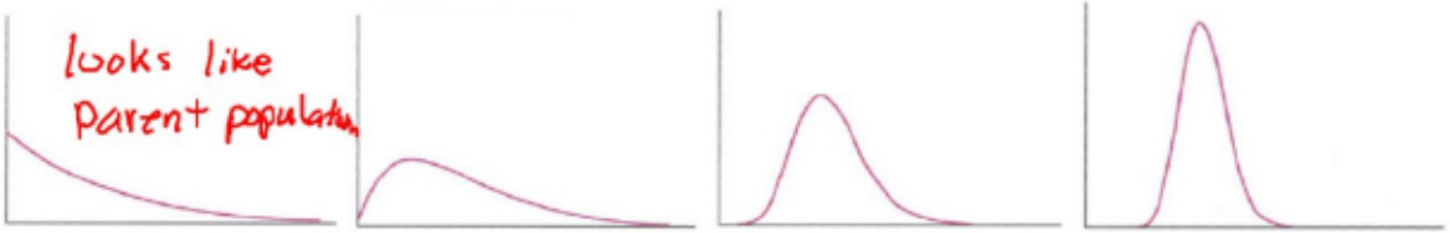
$$_7C_6 = 7(.5)^6(.5)^1$$

Binomial Setting

Comparing Data Sets (SOCS)

Surveys - Designing Samples

Learning Card for ral Limit Theorem	Name	Card #



n= 1 n= 5 n= 15 n= 30

The Central Limit Theorem discusses the Shape and only the Shape of the sampling distribution of x when n is sufficiently large → n ≥ 30 (sample size)

3 situations to consider:

Population has a normal dist. then the sampling dist. will be normal

z-scores ✓

probabilities ✓ w/ normal dist.

non-normal pop dist, small n, then sampling dist. will be non-normal

z-scores ✓

~~probabilities w/ normal dist~~

non-normal pop dist, large n, then sampling dist. will be approx. normal

z-scores ✓

probabilities ✓ w/ normal dist

Central Limit Theorem

Comparing Data Sets (SOCS)

Surveys - Designing Samples

Learning Card for | Name | Card #

Name It

1-Sample Z-interval for means

You sample 25 students using an SRS and get their average study hours per week of 5.3 hours. The population on study hours is normally distributed with a std dev of 1.2. Build a 95% confidence interval to estimate the mean study hours.

$\bar{x} = 5.3 \quad n = 25$

$\sigma = 1.2$

Conditions

Random? surveys - randomly selected? experiments - randomly assigned? ✓

Normal Pop?

- yes! → if parent pop is normal ✓
- No, $n \geq 30$ → Central Limit Theorem ✓
- No, $n < 30$ → Check graphs

Check graphs: histogram ✓ | box plot ✓ | norm prob plot (minor wiggles ok ✓; systematic dev. not ok)

✓ Bell shaped ✓ Symmetrical

Checking for Signs of non-normality

if conditions are not met... Then "proceed with Caution"

Calculate $\bar{x} \pm z^*\left(\frac{\sigma}{\sqrt{n}}\right)$

$5.3 \pm 1.96\left(\frac{1.2}{\sqrt{25}}\right)$

$(4.83, 5.77)$

Interpret

I am 95 % Confident that the Interval 4.83 to 5.77 Contains true Parameter of mean study hours (parameter of interest) of the North Forsyth High Students (context (overall population))

Confidence Level Interpretation: The method used to construct the interval will capture the true value about 95 % of the time in repeated sampling

z* values	.674	.841	1.036	1.282	1.645	1.96	2.054	2.326	2.576	?
for Confidence Level "C"	50%	60%	70%	80%	90%	95%	96%	98%	99%	100%

NiCCI...CICP Confidence Intervals - Mean σ known

Name it & Hypothesize It!

1 Sample T-test for means

Ruffles Chips bag claims only 328mg of Olestra per serving. You eat a bunch; you get seriously sick; you want to sue Frito-Lay for incorrect labeling; you collect your own random sample of 35 bags and find a mean of 354mg with a sample std. dev. of 83.5mg. Can you win the lawsuit?

one-sided

two-sided

Null Hypothesis H_0 $H_0: \mu = 328$

Alternative Hypothesis H_a $H_a: \mu > 328$

Statistical Signif (at level α) $\alpha = .05$

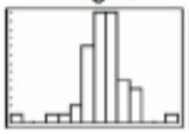
Conditions

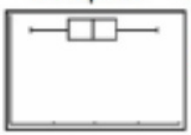
Random? → yes, stated ✓

Normal Pop? → yes ✓

→ NO → $n \geq 30$ → Central Limit Theorem

→ NO → $n < 30$ → histogram, box plot, norm prob plot





✓ minor wiggles

✗ Major dev. sys...

Checking for → Bell shape, symmetry

if conditions are not met... Then "Proceed w/caution"

Calculations

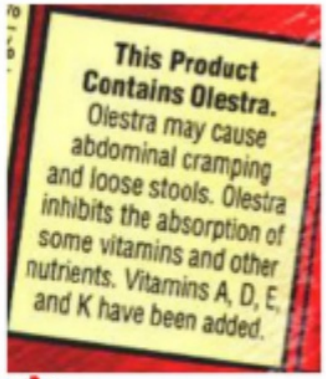
$$\text{Test Statistic} = \frac{\text{Statistic} - \text{Parameter}}{\text{Std. dev of the Statistic}}$$

$$t = \frac{\bar{x} - \mu_0}{\frac{s_x}{\sqrt{n}}} = \frac{354 - 328}{\frac{83.5}{\sqrt{35}}} = 1.84$$

$P(t > 1.84) = .037$

Interpret

if the P-value is low, the null must go b/c the p-value is low (.037 compared to $\alpha = .05$), we reject the null ($\mu = 328$) in favor of the alternative... the mean olestra is likely > 328 mg. per serving.



NiHiCCI — 1 Sample T Test for Means — σ unknown

Simulations - What's the Probability?

y=ax+b y=b₀+b₁x Least Squares Regression Line... LSRL

Comparing Data Sets (SOCS)

Surveys - Designing Samples

Learning Card for 2 Sample T-Test	Name	Card #

My girlfriend from Lambert wanted us to attend her Prom instead of North's Prom. I said that I couldn't compete with the Lambert group because they spend much more on average than the North students. To impress her, I pull out my AP Stat skills and come up with the following data: A sample of 18 random Lambert students spent an average of $345 with a sample standard deviation of 28.5, while a sample of 15 North students revealed an average of $319 with a sample standard deviation of 41.2. Is there really a difference or is this just due to random chance of different samples?

Name It: 2 Sample t-test for means

Hypothesize It:

$H_0: \mu_L = \mu_N$ or $\mu_L - \mu_N = 0$ $\quad H_a: \mu_L > \mu_N$ or $\mu_L - \mu_N > 0$

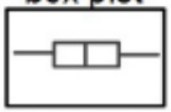
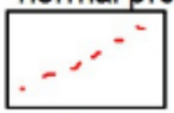
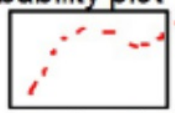
Conditions: Random? YES, stated

Independent? Are there 2 separate populations?

Normal Parent Population?

$n \geq 30$ → Central Limit Theorem

$n < 30$ →

histogram	box plot	normal probability plot	
			
bell shaped unimodal	symmetrical no outliers	minor wiggles ok!	systematic deviations not ok!

Calculations

Test Statistic $= \dfrac{est_{Diff} - hyp_{Diff}}{SD_{Diff}}$

$$t = \frac{(\bar{x}_L - \bar{x}_N) - (\mu_L - \mu_N)}{\sqrt{\frac{S_L^2}{n} + \frac{S_N^2}{n}}} = \frac{(345-319) - 0}{\sqrt{\frac{28.5^2}{18} + \frac{41.2^2}{15}}} = 2.07$$

Interpretation: P↓ (.025) vs. $\alpha = .05$ reject null (no diff), there is evidence that Lambert spends more!

$P(t > 2.07) = .025$

Significance Tests - 2 Sample T-Test (Means)

Comparing Data Sets (SOCS)

Surveys - Designing Samples

Learning Card for χ^2 (Chi Squared) Test for Homogeneity of Populations	Name	Card #

Is there a difference in the distribution of this categorical data across these various populations or is there homogeneity ?

2nd Matrix, Edit [A] & enter observed values → E.V.s calculated → [B]

Obs.

	N	S	
Y	50	30	80
N	30	10	40
D	10	20	30
M	40	20	60
	130	80	210

$E = \frac{r_{total} \times C_{total}}{total}$

$E = \frac{8 \times 13}{21}$

$E = 4.95$

Name it:

Hypothesize It:

H_0: The dist of the categories is the same for all pops

H_A: " " " is Not " " "

Conditions...

- must have independent SRS's from each pop.
- All E.V.'s > 1
- $\frac{1}{5} < 5$... no more than $\frac{1}{5}$ of the E.V. can be < 5

Calculate...

Build your tables

observed

$\frac{(10-18.6)^2}{18.6} = 4$

expected

	N	S
Y	49.5	30.4
N	24.8	15.2
D	18.6	11.4
M	37.1	22.9

Calculate χ^2 =

$\sum \frac{(O-E)^2}{E} = \frac{(50-49.5)^2}{49.5} + \ldots = 13.9$

$P(\chi^2 > 13.9) = .003$

Interpret...

Use table to get p-value

df	.25	.20	.15	.10	.05
1	1.32	1.64	2.07	2.71	3.84
2	2.77	3.22	3.79	4.61	5.99
3	4.11	4.64	5.32	6.25	7.81
4	5.39	5.99	6.74	7.78	9.49
5	6.63	7.29	8.12	9.24	11.07

P↓ (.003) vs. α(.05)

reject null of no diff...

there is evidence of a diff. between the populations on this categorical data.

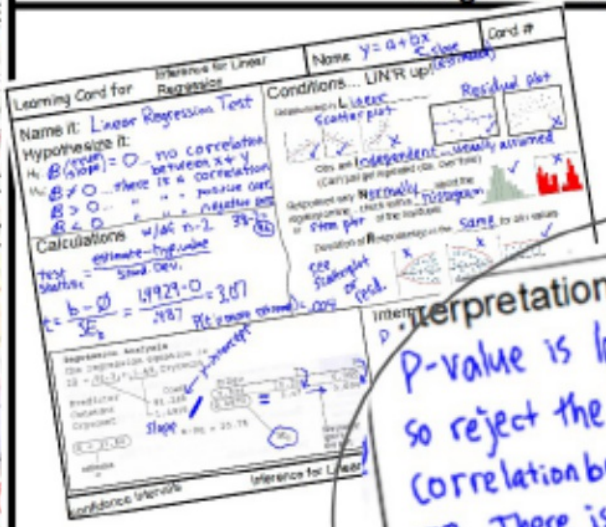
χ^2 (Chi Squared) Test for Homogeneity of Populations

y=ax+b $y=b_0+b_1x$ Least Squares Regression Line... LSRL

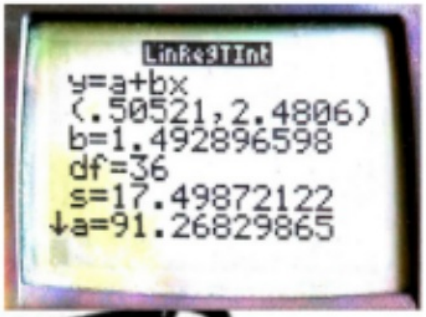
Comparing Data Sets (SOCS)

Surveys - Designing Samples

Learning Card for	Inference for Linear Regression... Conf Intervals	Name	Card #



Stat → Tests → LinRegTInt



Interpretation from T-Test

P-value is low (.004) vs. α(.05), so reject the null hyp of no correlation between crycount & IQ. There is strong evidence of a correlation between x & y.

slope ≠ 0 ? T-test

Coincides with the interpretation from the Linear Regression T-Test

Interpretation

We are 95% Confident that the Interval of (.5, 2.5) Contains the true Parameter (β → slope) stating that for every 1 increase in crycounts we predict IQ increases between .5 & 2.5.

plus

take note, zero is not in the interval... there is evidence of a correlation

Calculations

estimate ± (critical value × Std. Dev.)

↓

$b \pm t^* SE_b$ ← always given

↓ ↓ ↓

$1.49 \pm 2.042(.487)$ → (.5, 2.5)

↑ use t-dist chart w/ df = n−2

Binomial Setting

Thank you and go...
fill - in - the - Blank !

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