Using Hands-on Methods with Computer Simulations to Teach Sampling Distributions and Inference

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Abstract

In the past, we have used hands-on activities coupled with Java scripts on the web to teach students about sampling distributions and inference. However, students had difficulties connecting the hands-on activities with the java scripts. The hands-on activities are now duplicated on the computer using JMP scripts.

Goal

Using the hands-on activities and the JMP scripts, students will discover concepts related to sampling distributions and inference such as

- What is a sampling distribution?
- What does C% confident really mean?
- What is Type I error?
- What is Power?

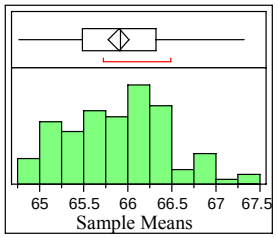
What is a sampling distribution?

Hands-on Activity

- Population of 250 values.
- Each student samples from population by hand using random number table.
  - n = 1
  - n = 5
  - n = 10
- Calculate sample mean.
- Combine sample means from class into histogram.

Computer Simulation

- Population
- JMP Script samples from population 100 times with n = 25.
- Records 100 sample mean values.
- Histogram of results.



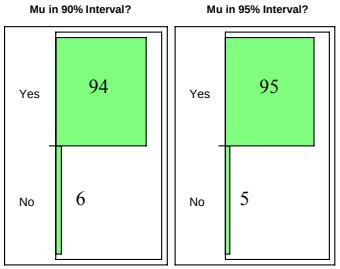
What does C% confidence really mean?

Hands-on Method

- Population of 250 values.
- Each student samples from population by hand using random number table with n = 10
- Calculate sample mean and confidence interval.
- Is μ in your confidence interval?
- How many people have μ in their confidence intervals?

Computer Simulation

- Population
- JMP Script samples from population 100 times with n = 25.
- Records 100 sample mean values and 100 confidence intervals.
- How many 90% and 95% confidence intervals contain μ.



What is Type I Error?

Hands-on Method

- Population of 250 values.
- Each student samples from population by hand using random number table with n = 10
- Calculate sample mean and z test statistic using true value of μ.
- Calculate p-value.
- Will you reject H_o at α = 0.1, 0.05, or 0.01?
- How many people will reject H_o?

Computer Simulation

- Population
- JMP Script samples from population 100 times with n = 25.
- Records 100 sample mean values, 100 z test statistics, and 100 p-values.
- How many times will you reject H_o?

Percent of Rejections of H_o

$\alpha = 0.1$	11%
$\alpha = 0.05$	5%
$\alpha = 0.01$	1%

What is power?

Problem: Two varieties of corn are planted in 36 plots in the same field. Do Type A and Type B produce different mean corn yields?

Convenience Assignment

A 130	A 149	A 139	B 155	B 137	B 145
A 149	A 133	A 152	B 131	B 147	B 136
A 141	A 156	A 137	B 146	B 132	B 148
A 150	A 142	A 155	B 136	B 152	B 133
A 139	A 155	A 139	B 147	B 137	B 153
A 155	A 138	A 150	B 137	B 145	B 136

Conclusion: The mean yield of Type A is slightly higher than Type B but the difference is not statistically significant.

Systematic Assignment

A 130	B 137	A 139	B 155	A 149	B 145
B 137	A 133	B 140	A 143	B 147	A 148
A 141	B 144	A 137	B 146	A 144	B 148
B 138	A 142	B 143	A 148	B 152	A 145
A 139	B 143	A 139	B 147	A 149	B 153
B 143	A 138	B 138	A 149	B 145	A 148

Conclusion: The mean yield of Type B is now slightly higher than Type A, but the difference is not statistically significant.

Why do two assignments give different results? What kind of assignment should be used?

Hands-on Activity

Students make a random assignment of the two varieties to the 36 plots using a 6-sided die. Using the TRUTH, students assign values to each of the 36 randomly assigned plots and conduct a hypothesis test to determine if Type A has a better mean corn yield than Type B.

THE TRUTH

A=130 B=118	A=149 B=137	A=139 B=127	A=167 B=155	A=149 B=137	A=157 B=145
A=149 B=137	A=133 B=121	A=152 B=140	A=143 B=131	A=159 B=147	A=148 B=136
A=141 B=129	A=156 B=144	A=137 B=125	A=158 B=146	A=144 B=132	A=160 B=148
A=150 B=138	A=142 B=130	A=155 B=143	A=148 B=136	A=164 B=152	A=145 B=133
A=139 B=127	A=155 B=143	A=139 B=127	A=159 B=147	A=149 B=137	A=165 B=153
A=155 B=143	A=138 B=126	A=150 B=138	A=149 B=137	A=157 B=145	A=148 B=136

A Random Assignment

B 118	A 149	A 139	A 167	A 149	A 157
B 137	B 121	B 140	A 143	B 147	B 136
B 129	B 144	A 137	B 146	B 132	A 160
B 138	A 142	A 155	B 136	A 164	A 145
A 139	A 155	A 139	A 159	B 137	A 165
B 143	B 126	B 138	B 137	B 145	A 148

Under the random assignment, there is an overwhelming statistically significant difference in mean corn yields between Type A and B, with Type A having higher mean yields.

Computer Simulation

- JMP script makes 100 random assignments of varieties A and B to the 36 plots.
- Complete test of
  - Ho: $\mu_A - \mu_B = 0$
  - Ha: $\mu_A - \mu_B \neq 0$
- Null hypothesis is incorrect ($\mu_A - \mu_B = 12$)
- How many times will you reject H_o?

Further Simulation

- Change true value of $\mu_A - \mu_B$
- Null hypothesis is still incorrect.
- How many times will you reject H_o?
- How does this relate to α?

Percent of Rejections of H_o

	$\mu_A - \mu_B = 3$	$\mu_A - \mu_B = 6$	$\mu_A - \mu_B = 12$
$\alpha = 0.05$	11%	46%	96%
$\alpha = 0.01$	1%	17%	88%