Live Session 4

1. Welcome/Intro (including polls)

2. Process Improvement Project Requirements

2. Hypothesis Testing – means and proportions

3. Chi Square Test for Independence

4. Assignments for next 2 weeks

5. Wrap up and Feedback

Process Improvement Project
-Requirements-

The final submission should be 1 file, in slide format, created in PowerPoint.

It should include 2 parts:

1) ***Executive summary slide*** **– 1 slide Storyboard (specific requirements below).**

2) ***Back-up slides*** **– additional 5-15 slides (specific requirements pgs. 3-4). This is not a repeat/copy of your storyboard. The back-up slides should detail and support the content of your storyboard.**

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1) *Executive Summary :: Storyboard* (should be presented in 1 PowerPoint slide)

- Follow the DMAIC steps
- Include the problem statement and baseline
- Utilize **at least 5 different** tools/techniques (present relevant key tools to best tell your story).
- Be readable; summarize and condense exhibits where necessary
- Use arrows, call out boxes, and balloons to highlight questions and key learnings
- Display data/charts supporting your findings and conclusions
- Show results or expected results

Process Improvement Project
-Requirements-

2) *Back-up slides* - following the Storyboard include 5-15 slides containing the answers to the following questions.

DEFINE

•What is your goal? How will you know if you’ve been successful?

•Have clear operational definitions been established for your inputs and outputs?

•What is the process you’re trying to improve? What are the current steps of the process?

MEASURE

•Include your Data Measurement Plan **or** Data Stratification Tree (see examples)

•What type of data did you collect (cost, cycle time, changeover time, yield, machine utilization, scrap, rework, defects, inventory)?

•Was that data continuous or discrete?

•Did you collect your own data or did you use existing data?

•How much data did you collect and why? What is your ideal sample size using the sample size formula? What is the risk if you collected fewer samples?

•How was your data collected? Describe the methods you used to collect it.

Process Improvement Project
-Requirements-

2) *Back-up slides continued:*

MEASURE (continued)

- Where could you have measurement error? How much measurement error do you have? What could you do to minimize your measurement error?

ANALYZE

- What tools did you use to analyze the data? Why?
- What is the data telling you? What did you discover?
- What is the SQL for the old and new process?

IMPROVE

- What solutions did you propose and/or implement? Did you successfully improve your process? What did you learn about your process?

CONTROL

- How will you use this information to “hold the gains” of your improvement or make the next round of improvements in your process?

Name of your project

Process owner: or your Name

Key Dates --->	Team Launch	Define	Measure	Analyze	Improve	Control

DEFINE

MEASURE

ANALYZE

IMPROVE

STORYBOARD TEMPLATE

CONTROL

TEAM MEMBERS

Measure Phase: Choose <u>one</u>

Data Stratification Tree

Example

Questions About Process

- Are orders impacted by the sales rep skill-levels (systems, product, pricing, listening, ability to follow the process)?
- What % of the calls are order related?
- Does the Sales Rep have the right skills to improve selling more orders?
- Do new orders vary by month ?
- Do new orders change by the receptiveness of the customer?
- Are orders impacted by call duration?
- Are orders impacted by call wait ti[illegible]
- Are orders impacted by pricing iss[illegible]
- Are orders impacted by whether o[illegible] Sales Rep follows the written process?
- Do new orders vary by the availability of the product (not on backorder)?
- Do the current targets impact orders?

New Orders

(Output Y)

Stratification factors
X Variables

- Skill level
- Type of call
- Training
- Time of year (mo.)
- Custo[illegible]
- [illegible] d[illegible]on
- [illegible]ait time
- Pricing Issue
- Written process
- No.of backorders
- Target settings (calls, orders, revenue)

Measurements

- •% of orders per Sales Rep by skill level type
- •average & range of Sales Rep skill levels
- •% type of call
- •no. of h[illegible]s of t[illegible]r month
- [illegible]l or[illegible] p[illegible] month
- [illegible]ew [illegible]er[illegible] of [illegible]l orders
- •% [illegible]w [illegible]r r[illegible] of total revenue by month
- [illegible]om[illegible] attitude rating by order type
- •Average call duration for xyz order vs. other orders
- •wait time for each call
- •% of calls transferred to OB due to pricing issues
- •mystery call /silent monitoring results (points per call)
- •% of orders resulting in backorders
- •calls, orders, total rev, rev per mo. per Sales Rep

Data Measurement Plan

Example

Performance Measure	Data Source and Location	How Will Data Be Collected	Who Will Collect Data	When Will Data Be Collected	Target Sample Size
•% of orders per Sales Rep by skill level type •average & range of Sales Rep skill levels	•Susie	•Develop rating scale & assess performance	•Susie	5/12	N/A
•% type of call	•Manual data collection	•Use data collection form	•All	5/11-6/2	1000 calls
•no. of hours of training per month	•John's training spreadsheet	•Manual data collection	•John	5/20	12 mo
• total orders placed by month •% new orders are of total orders •% order revenue of total revenue by month	•IB performance reports	•Pull from report	[illegible]	By 6/3	28 mo
•customer attitude rating by order type	•Manual data collection	[illegible]	[illegible]	5/11 - 6/2	500 orders
•Average call duration for new order vs. other	•Manual data collection	[illegible]	•All	5/11 - 6/2	500 orders
•wait time for each call	•Obtain fro[illegible]	[illegible]	•Leanne	tbd	tbd
•% of calls transferred to OB due to p[illegible] issues	[illegible]	[illegible]	•All	5/11 - 6/2	1000 calls
•mystery call /silent monitoring results [illegible] call)	[illegible] results	•Compile Pamela's data	•Leanne	By 6/3	30
•% of orders resulting in backord[illegible]	•Manual data collection	•Use data collection form	•All	5/11 - 6/2	500 orders
•calls, orders, total rev, per Sales R[illegible] month	•IB performance reports	•Pull from report	•Susie	By 6/3	28 mo
• No. of inbound calls per day	•IB performance reports	•Pull from report	•Susie	By 6/3	28 mo
•order revenue per Sales Rep per month	•IB performance reports	•Pull from report	•Susie	By 6/3	28mo
• Total revenue per month	•IB performance reports	•Pull from report	•Susie	By 6/3	28 mo
• Revenue per month by product type	•SN report	•Pull from report	•Leanne	By 6/3	ytd

Process Improvement Project
-Rubric-

Content Requirements	Possible Points
A) An executive summary is provided in the storyboard format including: Is the storyboard presented in 1 PowerPoint slide? Follows DMAIC? Are tools/graphs/charts used and clearly visible? Do they support findings and conclusions Are arrows, call-out boxes, etc. used to summarize, highlight questions and key learnings? Are expected results clear? And next steps noted?	5.0
B)Is it a cohesive presentation opening with the business process and problem statement? The back-up slides (5-15) detail and support the storyboard content.	2.0
C) Was the success measure clearly identified, operationally defined and baseline identified? (Was the data identified as continuous or discrete, includes SQL?)	3.0
D) Was the data measurement plan or data stratification tree included?	1.0
E) Was the data collection method identified?	1.0
F) Was there rationale for the sample size taken? Use of the formula? Is there any reference to measurement error and how to minimize?	1.0
G) Are at least 5 different tools and techniques clearly identified? Are the tools linked/ pertinent to the data analysis?	5.0
H) Does the data analysis clearly tie to the problem conclusion? Is the “discovery” clear to the reader?	2.0
Total	**20**

Analyze

Description:

Analyze, describe, and present the data to discover the root cause(s), identify/prioritize critical inputs (x's), determine the inputs impact on the output.

Week 3 & 4

Key Concepts:
Inferential statistics, common distributions, developing a hypothesis, determining the likelihood some event happens based on a sample (calculating probabilities), Using the normal distribution as the "go to" distribution.

Project:
Write a null and alternative hypothesis statement.

Tools:
Hypothesis testing
Chi-square test for independence

Week 5

Key Concepts:
Collecting sample data, how confidence intervals and sample size are related.

Project:
Utilize the sample size formula.

Tools:
Confidence intervals.

Week 6 &7

Key Concepts:
Determining input's (x) impact on the output (y).

Project:
Use regression to identify relationships between the output (y) and inputs (x's).

Tools:
Correlation
Simple linear regression
Multiple regression
Scatterplot
Trend/ line chart
Pareto chart
Fishbone (cause/effect) diagram

Hypothesis Testing – alpha, beta, and p-value

Type I and Type II Errors

In a criminal trial, the defendant is innocent until proven guilty. The jury must evaluate the truth of two competing hypotheses:

H_0: defendant is not guilty versus *H_a: defendant is guilty*

	Reality	
Jury's decision	H_0 true: Defendant did not commit the crime	H_0 false: Defendant did commit the crime
Reject H_0: Find defendant guilty	Type I error	Correct decision
Do not reject H_0: Find defendant not guilty	Correct decision	Type II error

In statistics, the two incorrect decisions are called Type I and Type II errors.

Two Types of Errors

- **Type I error:** To reject H_0 when H_0 is true.
- **Type II error:** To not reject H_0 when H_0 is false.

Type I and Type II Errors

We can make decisions about population parameters using the limited information available in a sample because we base our decisions on *probability*.

•When the difference between the sample mean and the hypothesized mean is large, then the null hypothesis is *probably* not correct.

• When the difference is small, then the data are *probably* consistent with the null hypothesis.

But we don't know for sure.

The probability of a Type I error is denoted as ***α*(alpha).** We set the value of *α* to be some small constant, such as 0.01, 0.05, or 0.10, so that there is only a small probability of rejecting a true null hypothesis.

The **level of significance** of a hypothesis test is another name for *α*.

The probability of a Type II error is denoted as ***β*(beta).** This is the probability of not rejecting the null hypothesis when it is false.

The *p*-Value

In this section, we introduce the *p*-value method, which works by comparing one probability (the *p*-value) to another probability (α).
The ***p*-value** is a measure of how well (or how poorly) the data fit the null hypothesis.

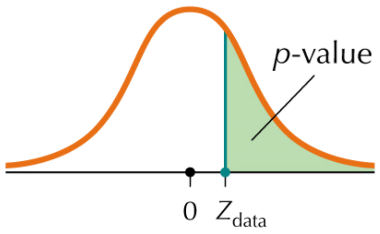
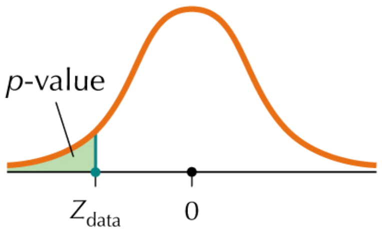
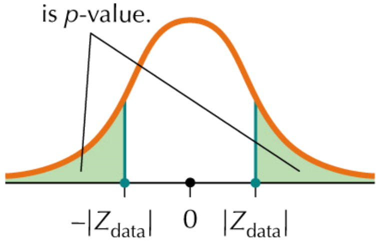
_p_-Value

The ***p*-value** is the probability of observing a sample statistic at least as extreme as the statistic observed, if we assume that the null hypothesis is true.

The method for calculating *p*-values depends on the form of the hypothesis test:

- When the *p*-value is in the right (upper) tail, we have a right-tailed test.
- When the *p*-value is in the left (lower) tail, we have a left-tailed test.
- When the *p*-value lies in both tails, we have a two-tailed test.

The *p*-Value

Type of hypothesis test	*p*-Value is tail area associated with Z_{data}
Right-tailed test $H_0: \mu \le \mu_0$ versus $H_a: \mu > \mu_0$ $p\text{-value} = P(Z > Z_{data})$ Area to right of Z_{data}	
Left-tailed test $H_0: \mu \ge \mu_0$ versus $H_a: \mu < \mu_0$ $p\text{-value} = P(Z < Z_{data})$ Area to left of Z_{data}	
Two-tailed test $H_0: \mu = \mu_0$ versus $H_a: \mu \ne \mu_0$ $p\text{-value} = P(Z > \lvert Z_{data}\rvert) + P(Z < -\lvert Z_{data}\rvert)$ $= 2 \cdot P(Z > \lvert Z_{data}\rvert)$ Sum of the two tail areas.	

The rejection rule for performing a hypothesis test using the *p*-value method is:

- **Reject H_0 when the *p*-value ≤ *α*.**
- **Otherwise, do not reject H_0.**

Hypothesis Testing – means and proportions

Choosing the hypothesis test

Continuous

One Sample

One-Sample Hypothesis Tests for Continuous Data (Purple)

Select:	Two-tail test	One-tail test	
	Two-tail	Lower/left-tail	Upper/right-tail
	H_0: $\mu = \mu_0$	H_0: $\mu \ge \mu_0$	H_0: $\mu \le \mu_0$
	H_a: $\mu \ne \mu_0$	H_a: $\mu < \mu_0$	H_a: $\mu > \mu_0$
Choose:	Sample size		
	Large	Small	
	$n \ge 30$	$n < 30$	
	(or σ known)	(or σ unknown)	
Calculate:	Test statistic		
	$Z = \dfrac{\bar{x}-\mu_0}{\frac{s}{\sqrt{n}}}$	$t = \dfrac{\bar{x}-\mu_0}{\frac{s}{\sqrt{n}}}$	
	Can replace s with σ if known	$df = n - 1$	
Identify:	p-value		
	Two-tail	Lower/left-tail	Upper/right-tail
	p = 2 × area past Z or t	p = area left of Z or t	p = area right of Z or t

Two Sample

Two-Sample Hypothesis Tests for Continuous Data (Green)

Select:	Two-tail test	One-tail test	
	Two-tail	Lower/left-tail	Upper/right-tail
	H_0: $\mu_1 = \mu_2$	H_0: $\mu_1 \ge \mu_2$	H_0: $\mu_1 \le \mu_2$
	H_a: $\mu_1 \ne \mu_2$	H_a: $\mu_1 < \mu_2$	H_a: $\mu_1 > \mu_2$
Choose:	Sample size		
	Large	Small	
	$n_1 + n_2 \ge 30$	$n_1 + n_2 < 30$	
	(or σ known)	(or σ unknown)	
Calculate:	Test statistic		
	$Z = \dfrac{\bar{x}_1-\bar{x}_2}{\sqrt{\frac{s_1^2}{n_1}+\frac{s_2^2}{n_2}}}$	$t = \dfrac{\bar{x}_1-\bar{x}_2}{\sqrt{\frac{s_1^2}{n_1}+\frac{s_2^2}{n_2}}}$	
		$df = n_1 + n_2 - 2$	
Identify:	p-value		
	Two-tail	Lower/left-tail	Upper/right-tail
	p = 2 × area past Z or t	p = area left of Z or t	p = area right of Z or t

Discrete

One Sample

One-Sample Hypothesis Tests for Discrete Data (Orange)

Select:	Two-tail test	One-tail test	
	Two-tail	Lower/left-tail	Upper/right-tail
	H_0: $p = p_0$	H_0: $p \ge p_0$	H_0: $p \le p_0$
	H_a: $p \ne p_0$	H_a: $p < p_0$	H_a: $p > p_0$
Choose:	Sample size		
	Must have	Where	
	$np \ge 5$	$p = \dfrac{X}{n}$	
	$n(1-p) \ge 5$	X = no. of items of interest in sample	
	$n \ge 30$		
Calculate:	Test statistic		
	$Z = \dfrac{p-p_0}{\sqrt{\frac{p_0(1-p_0)}{n}}}$		
Identify:	p-value		
	Two-tail	Lower/left-tail	Upper/right-tail
	p = 2 × area past Z	p = area left of Z	p = area right of Z

Two Sample

Two-Sample Hypothesis Tests for Discrete Data (Pink)

Select:	Two-tail test	One-tail test	
	Two-tail	Lower/left-tail	Upper/right-tail
	H_0: $p_1 = p_2$	H_0: $p_1 \ge p_2$	H_0: $p_1 \le p_2$
	H_a: $p_1 \ne p_2$	H_a: $p_1 < p_2$	H_a: $p_1 > p_2$
Choose:	Sample size		
	Must have	Where	
	$n_1 + n_2 \ge 30$	$p_1 = \dfrac{X_1}{n_1}$ and $p_2 = \dfrac{X_2}{n_2}$	
		X = no. of items of interest in sample	
Calculate:	Test statistic		
	$Z = \dfrac{p_1-p_2}{\sqrt{\frac{x_1+x_2}{n_1+n_2}\left[1-\frac{x_1+x_2}{n_1+n_2}\right]\left[\frac{1}{n_1}+\frac{1}{n_2}\right]}}$		
Identify:	p-value		
	Two-tail	Lower/left-tail	Upper/right-tail
	p_1 = 2 × area past Z	p_1 = area left of Z	p_1 = area right of Z

Calculating the p-value

Test statistic:	z		t
two tail	if z value is less than 0:	=2*(NORM.S.DIST(z, TRUE))	=T.DIST.2T(t, df)
	if z value is greater than 0:	=2*(1-(NORM.S.DIST(z, TRUE)))	
lower/left tail	=NORM.S.DIST(z, TRUE)		=T.DIST(t, df, TRUE)
upper/right tail	=1-(NORM.S.DIST(z, TRUE))		=T.DIST.RT(t, df)

How do we address hypothesis test questions?

Steps for solving problems:

1. What type of data is this?

2. What other relevant information is found in this problem?
List out all of the items provided:

3. What test/formula do we use?

4. Calculate the values.

5. Interpret the result.

Example – Hypothesis Test (continuous)

A researcher believes that the mean weight of competitive runners is about 140 pounds. A sample of 36 elite distance runners has a mean weight of 136 pounds and a standard deviation of 12 pounds. Is there convincing evidence that the average weight of the elite distance runners is less than 140 pounds?

What is Ho?
What is Ha?
What test will you use?
What is the test statistic?
What is your p-value?
For an α of 0.05, what is your conclusion?

1. What type of data is this?
2. What other relevant information is found in this problem?
3. What test/formula do we use?
4. Calculate the values.
5. Interpret the result.

Example – Hypothesis Test (continuous)

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What is Ha?
What test will you use?
What is the test statistic?
What is your p-value?
For an α of 0.05, what is your conclusion?

Breakout – Hypothesis Test

A national survey states that the average price Americans pay for a frozen pizza is \$2.90. After running a hypothesis test for

Ho: $\mu \leq 2.90$

Ha: $\mu > 2.90$

with alpha = .05, the decision is made to reject the null hypothesis. Which of the following is the best interpretation of our results?

A) The data prove that Americans will spend more than \$2.90 on a frozen pizza.

B) There is insufficient evidence at the alpha = .05 level that the average amount spent by Americans on a frozen pizza is greater than \$2.90.

C) There is insufficient evidence at the alpha = .05 level that the average amount spent by Americans on a frozen pizza is \$2.90.

D) There is sufficient evidence at the alpha = .05 level that the average amount spent by Americans on frozen pizza is more than \$2.90.

Chi Square – for Categorical Data

χ^2 Test for Independence

To determine whether two variables are independent using the data in a contingency table, we use a χ^2 **test for independence**. Like the goodness of fit test, this test is based on a comparison of the observed frequencies with expected frequencies.

χ^2 Test for Independence

To determine whether two categorical variables are independent using the data in a contingency table, we use a χ^2 **test for independence.** The hypotheses take the form:

H_0: Variable A and Variable B are independent.
H_a: Variable A and Variable B are dependent.

We compare the observed frequencies with the frequencies we expect if we assume the null hypothesis is correct. Large differences lead to the rejection of the null hypothesis.

Expected Frequencies

To determine whether two variables are independent using the data in a contingency table, we use a χ^2 **test for independence**. Like the goodness of fit test, this test is based on a comparison of the observed frequencies with expected frequencies.

Expected Frequencies for a χ^2 Test for Independence

The expected frequencies for the cells of a contingency table in a χ^2 test for independence are given by

$$\text{expected frequency} = \frac{(\text{row total})(\text{column total})}{\text{grand total}}$$

<u>Actual (observed) Frequencies</u>

Response	Age Group: Gen Nexter (18–25)	26+	Total
Very happy	180	330	**510**
Pretty happy	378	435	**813**
Not too happy	42	135	**177**
Total	**600**	**900**	**1500**

<u>Expected Frequencies</u>

Response	Age Group: Gen Nexter (18–25)	26+
Very happy	$\frac{(510)(600)}{1500} = 204$	$\frac{(510)(900)}{1500} = 306$
Pretty happy	$\frac{(813)(600)}{1500} = 325.2$	$\frac{(813)(900)}{1500} = 487.8$
Not too happy	$\frac{(177)(600)}{1500} = 70.8$	$\frac{(177)(900)}{1500} = 106.2$

χ^2 Test for Independence

χ^2 Test for Independence: *p*-Value Method

Step 1: State the hypotheses and check the conditions.

Step 2: Calculate the test statistic $\chi^2_{\text{data}} = \sum \frac{(O_i - E_i)^2}{E_i}$

Or use the Chitest formula in excel

Step 3: Find the *p*-value.

Step 4: State the conclusion and the interpretation.

Discussion – Chi Square Example

Hypothesis												
Ho: ________age_________ and _____beverage type________ are independent												
Ha: _________age_______ and _______beverage type_______ are not independent												
(Actual) Observed frequencies						Expected frequencies						
	Coffee	Flavored Bev	Tea	Total			Coffee	Flavored B	Tea	Total		
Young	35	30	22	87		Young	39.5	27.4	20.1	87		
Middle Age	30	33	19	82		Middle Age	37.3	25.8	18.9	82		
Old	55	20	20	95		Old	43.2	29.9	22.0	95		Probability
Totals	120	83	61	264		Totals	120	83.0	61.0	264		0.0258

1. What is your p value (probability)?
2. What level of Alpha would you reject Ho?
3. Given the p value and the Alpha you chose, would you accept or reject Ho?
4. What does it mean – that you reject or accept?
5. What would you do next for further investigation or for your coffee shop business?

Next two weeks

1.Project Next Steps - Measure Phase

Measure/Analyze tools

Insights about the problem

2. Coursework BLT's:

4.5 Test Your Knowledge: Gender Differences

*4.6 Relate Chi-Square to Your Project

5.6 Test Your Knowledge

*5.7 Relate Sample Size to Your Project

3. Assignments:

Homework #2: *(worth 3 points)*

3 days after live session 4

LaunchPad Assignments

- Chapter **9 Online Quiz** (unlimited attempts)
- Complete **StatTutor:** Chapter **11** – Expected counts in 2-way tables

Upcoming assignment:

Homework #3: *(worth 2 points)*

3 days after live session 5

LaunchPad Assignments

- Chapter **8 Online Quiz** (unlimited attempts)