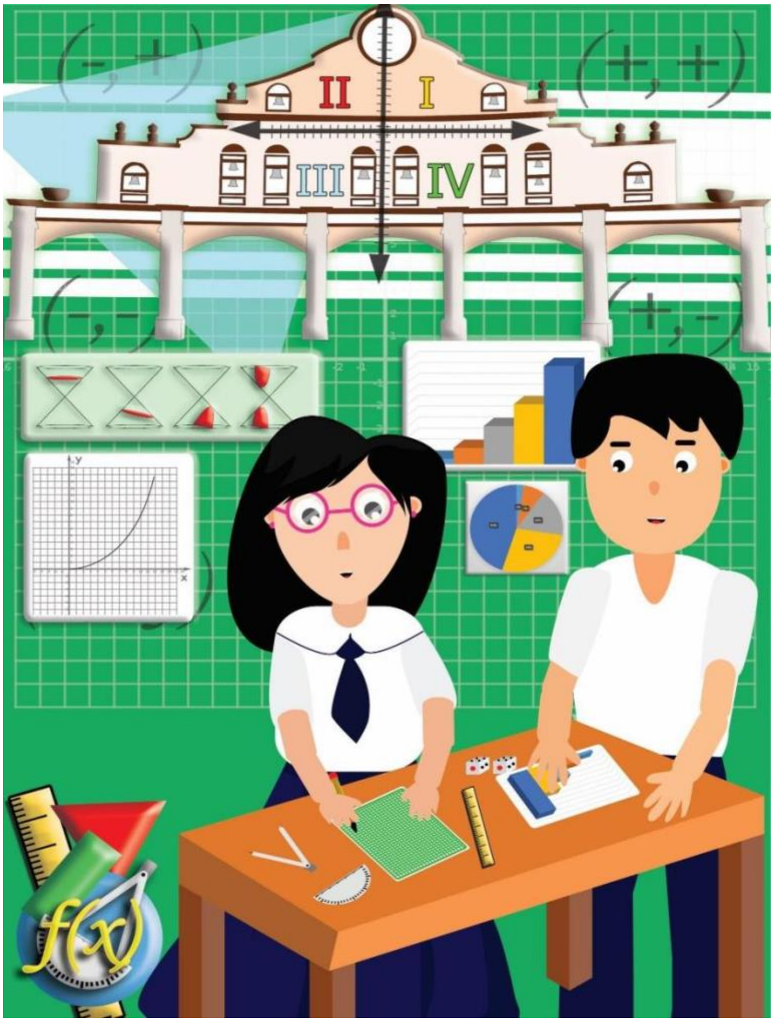
Senior High School

Department of Education
National Capital Region
SCHOOLS DIVISION OFFICE
MARIKINA CITY

STATISTICS AND PROBABILITY

Quarter 3: Module 8
Confidence Interval



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What I Need to Know

Hello Grade 11 learners! In this module, you will learn how to:

Illustrate the t-distribution **M11/12SP-IIIg-2**,
Identify percentiles using the t-table **M11/12SP-IIIg-5**,
Identify the length of a confidence interval **M11/12SP-IIIj-1**,
Compute for the length of the confidence interval **M11/12SP-IIIj-2**,
Compute for an appropriate sample size using the length of the interval **M11/12SP-IIIj-3** and;
Solve problems involving sample size determination **M11/12SP-IIIj-4** .

You can say that you have understood the lesson in this module if you can already:

1. Estimate the Confidence Interval for the Population Mean when σ is known or n ≥ 30,
2. Estimate the Confidence Interval for the Population Mean when σ is known and n < 30 and
3. Solve problems involving sample size based on confidence level..

What I Know

Read each item carefully then write the letter that corresponds to the correct answer.

1. If 40 basketball players showed that their average score was 9.7 points per game. The standard deviation of the population is 6. What is the point estimate of population mean?
   A. 6 B. 9.7 C. 40 D. none
2. If n= 16, s = 3.1 and 95% confidence, what is the margin of error ?
   A. 1.652 B. 1.653 C. 1.654 D. 1.655
3. The BPP/FBS students of SHS in MHS made chocolate cakes. The average weight of 25 chocolate bars selected from a normally distributed population is 200 grams with sample standard deviation of 10 grams. Find the interval estimate using the 95% confidence level.
   A. [195.872, 203.123] C. [196.872, 203.123]
   B. [195.872, 204.128] D. [196,872, 204.128]
4. A senior high school registrar wishes to estimate the mean age of all grade 11 students currently enrolled. In a random sample of 30 students, the mean age is

found to be 16.5. The standard deviation is 1.5 years, and the population is normally distributed at $\alpha = 0.10$ confidence. Find the margin of error of the population mean.

A. 4.3 B. 4.5 C. 0.44 D. 0.45

5. Find the $t_{\frac{}{2}}$ of 90% confidence interval if n = 3, s = 3, $\bar{X}$ = 82.5.

A. 1.353 B.1.920 C.2.353 D. 2.920

6. Which of the following symbols denotes population mean?

A. μ B. σ C. $\bar{X}$ D. s

7. A simple random sample of 20 cats weighs 8.5 pounds. If the standard deviation of the population of all cats' weights is 1.8 pounds, find the confidence interval of all cats with 90% confidence.

A. [7.79, 9.19] C. [7.79, 9.20]

B. [7.80, 9.20] D. [7.80, 9.19]

8. Using #7, determine the degree of freedom.

A. 17 B. 18 C. 19 D. 20

9. Given: E = 0.50, 95% Confidence, ⌠ = 3.5. What is the sample size?

A. 188 B.189 C. 190 D. 191

10. Which of the following symbols denotes a population standard deviation?

A. μ B. ⌠ C. $\bar{X}$ D. s

11. Round up the value 462.25.

A. 462 B. 462.2 C. 462.3 D. 463

12. Jalliyah wants to estimate a population mean based on a random sample n observation and the estimated standard deviation was 11.7. If the margin of error is within 1.52, and the probability is equal to 0.95, how many observations should be included in your sample?

A. 225 B. 226 C. 227 D. 228

13. A teacher wants to estimate the number of hours that grade 7 student spend watching tik-tok in his/her mobile. A sample of 50 grade 7 students was observed to have a mean viewing time of 3 hours. The population is normally distributed with a population standard deviation 0.5 hours. What is the best point estimate of the population mean?

A. 2 B. 3 C. 4 D. 5

14. In a certain HUMSS class, the average test score of all students was measured to be 82 with a standard deviation of 6.5. If the margin of error was calculated to be 1.8 at a 95% confidence level, how many students were in the class?

A. 51 B. 50 C. 49 D. 48

15. Find the minimum sample size when estimating the population proportion given 99% confidence, E = 0.05 and $\hat{p}$ = 0.35.

A. 605 B. 606 C. 607 D. 608

LESSON 1: ESTIMATING THE CONFIDENCE INTERVAL FOR THE POPULATION MEAN WHEN ⌠ IS KNOWN OR n ≥ 30

What's In

A. Answer the following:

1. Find the critical value $Z_{\frac{\alpha}{2}}$ of
   - a. 90% Confidence level
   - b. 95% Confidence level
   - c. 99% Confidence level
   - d. 98% Confidence level
   - e. 80% Confidence level

2. _____________is a continuous, symmetric, and bell-shaped distribution of a variable.

3. The expression $\frac{\sigma}{\sqrt{n}}$ is referred to as ________________.

4. In a standard normal distribution, the mean is ______________and the standard deviation is ______________.

5. What is the z-value that correspond to an area of 0.4495?

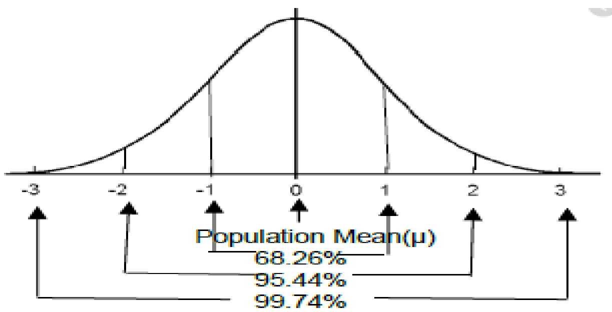
What's New

Hours spend practicing "Taga Marikina Ako Dance"

A researcher wants to estimate the number of hours in a week of SHS students spend practicing "Taga Marikina Ako Dance" in a week. A sample of 50 SHS students was observed to have a mean dancing time of 3 hours. The population is normally distributed with a population standard deviation 0.5 hours. Find the point estimate of the population mean if the confidence interval of the true population mean is 80%.

What is It

In a standard normal distribution, the mean (μ) is 0 and the standard deviation (σ) is 1. The horizontal base of the curve is the z-value or the z-scores. These z-value is also called the confidence coefficients/critical value.



From the previous lesson, the commonly use confidence intervals and its confidence coefficient/critical values are

$$90\% \text{ confidence interval, } Z_{\frac{\alpha}{2}} = \pm 1.65$$

$$95\% \text{ confidence interval, } Z_{\frac{\alpha}{2}} = \pm 1.96$$

$$99\% \text{ confidence interval, } Z_{\frac{\alpha}{2}} = \pm 2.58$$

A point estimate is a specific numerical value estimate of a parameter.
When we describe population values, we want to be confident about our estimate. Other than the point estimate, we can use a range of values. This range of values is called interval estimate.

An interval estimate, called a *confidence interval*, is a range of values that is used to estimate a parameter. This estimate may or may not contain the true parameter value.

Confidence Interval Data Requirements
To express a confidence interval, you need three pieces of information.
1. *Confidence level*- refers to the percentage of all possible samples within the true population parameter. The three commonly confidence interval used: the 90%, the 95%, and the 99% confidence intervals.
2. *Statistic*- is a characteristic of a sample, used to estimate the value of population parameter.
3. *Margin of error* (E)-expresses the maximum expected difference between the true population parameter and a sample estimate of that parameter.

Margin of error = Critical value x Standard error of the statistic

$$\boxed{\boldsymbol{E} = \boldsymbol{Z}_{\frac{\alpha}{2}}\left(\frac{\sigma}{\sqrt{n}}\right)}$$

Formula for the Confidence Interval of the Mean for a Specific α

$$\overline{X} \pm Z_{\frac{\alpha}{2}}\left(\frac{\sigma}{\sqrt{n}}\right)$$

or

$$\overline{X} - Z_{\frac{\alpha}{2}}\left(\frac{\sigma}{\sqrt{n}}\right) < \mu < \overline{X} + Z_{\frac{\alpha}{2}}\left(\frac{\sigma}{\sqrt{n}}\right)$$

Where: $\overline{X}$ = point of estimate
$Z_{\frac{\alpha}{2}}$ = critical value
σ = population standard deviation
n = sample size

or

$$\overline{X} - E < \mu < \overline{X} + E$$

Confidence interval = sample statistic $\pm$ Margin of error

In the general formula for determining the interval estimate for the parameter μ, the $\overline{X} - Z_{\frac{\alpha}{2}}\left(\frac{\sigma}{\sqrt{n}}\right)$ is called the **lower confidence boundary or limit** and the other $\overline{X} + Z_{\frac{\alpha}{2}}\left(\frac{\sigma}{\sqrt{n}}\right)$ is the **upper confidence boundary or limit.**

Steps Process in Computing the Interval Estimate.
1. Identify a sample statistic. (e.g., mean μ)
2. Select a confidence level. The 90%, 95%, or 99% confidence Levels are commonly used; but any percentage can be used.
3. Find the margin of error.
4. Specify the confidence interval.

Illustrative examples:
1. Given: The sampled population is normally distributed, $\overline{X} = 74.04$, $\sigma = 0.43$, $n = 32$.
   a. What is the point estimate?
   b. Find the 95% confidence interval for mean μ.

STEPS
1. Identify a sample statistic: The parameter of interest is the mean μ.
   a. The point estimate of the population mean μ is 74.04.
2. Select the confidence level: 95% confidence level, $Z_{\frac{\alpha}{2}} = \pm 1.96$
3. Find the margin of error:

$$E = \pm Z_{\frac{}{2}}\left(\frac{}{\sqrt{n}}\right)$$

$E = \pm 1.96\left(\frac{0.43}{\sqrt{32}}\right)$, where σ = 0.43 and n = 32

$$\boxed{\mathbf{E = \pm\ 0.15}}$$

4. Specify the confidence interval:

$$\overline{X} - Z_{\frac{\alpha}{2}}\left(\frac{\sigma}{\sqrt{n}}\right) < \mu < \overline{X} + Z_{\frac{\alpha}{2}}\left(\frac{\sigma}{\sqrt{n}}\right)$$

$$\overline{X} - E < \mu < \overline{X} + E$$

or

$$74.04 - 0.15 < \mu < 74.04 + 0.15$$

$$\boxed{73.89 < \mu < 74.19}$$

b. Confidence Interval*:* *[73.89,74.19] or 73.89 to 74.19*
Lower Confidence Limit: *73.89*
Upper Confidence Limit: *74.19*

Conclusion*:* We can say with 95% confidence that the interval between 73.89 and 74.19 contains the population mean μ based on the sample size 32.

2. A sample of 60 Grade 11 students' ages was obtained to estimate the mean age of all Grade 11 students. $\overline{X}$ = 16.3 years and the population variance is 25.

a. What is the point estimate for μ?
b. Find the 90% confidence interval for μ.

Solution:

a. Point Estimate: $\overline{X}$ = 16.3
b. 90% confidence interval for mean μ

Margin of error : $E = \pm Z_{\frac{\alpha}{2}}\left(\frac{\sigma}{\sqrt{n}}\right)$

$E = \pm\ 1.65\left(\frac{5}{\sqrt{60}}\right)$

$\boxed{\boldsymbol{E = 1.07}}$

where:
90% CL, $Z_{\frac{\alpha}{2}} = \pm 1.65$;
n = 60; $\sigma^2 = 25$, $\sigma = 5$

Confidence Interval: $\overline{X} - E < \mu < \overline{X} + E$
$16.3 - 1.07 < \mu < 16.3 + 1.07$
$\boxed{\boldsymbol{14.96 < \mu < 17.37}}$

Confidence Interval: *[14.96,17.37] or 14.96 to 17.37*
Lower Confidence Limit: *14.96*
Upper Confidence Limit: *17.37*

nately between 14.96 years old and 17.37 years old contain the population mean μ based on grade 11 student's age.

What's More

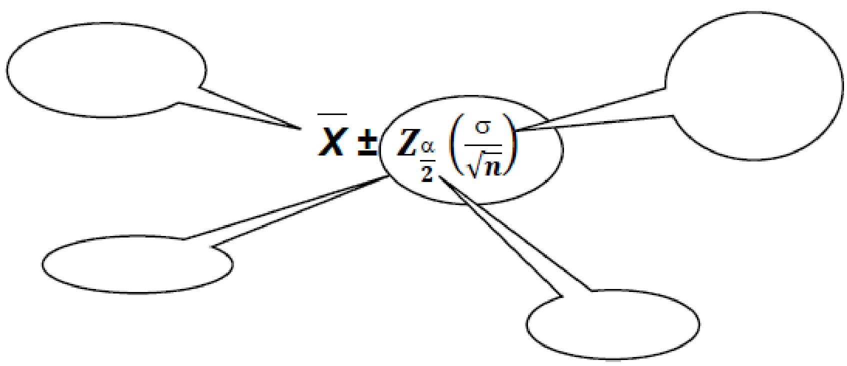
Solve for the given problem below. Round off your answer in 2 decimal places.

A researcher wants to estimate the number of hours in a week of SHS students spend practicing "Taga Marikina Ako Dance" in a week. A sample of 50 SHS students was observed to have a mean dancing time of 3 hours. The population is normally distributed with a population standard deviation 0.5 hours with 80% confidence level.

a. Find the critical value, standard error and margin of error.
b. Find the confidence interval using the 80% confidence level.
c. Identify the lower and upper confidence limits.
d. Solve and illustrate your answer in Normal Curve Distributions.
e. Make a conclusion on Hours spend practicing "Taga Marikina Ako Dance."

What I Have Learned

Write the terms describing the symbols in finding the confidence interval.



1. The three commonly confidence interval used are _______________.
2. The second step in computing the confidence interval is ________________.
3. An interval estimate also called ________________ is a range of values that is used to estimate a parameter.
4. _______________is the product of critical vale and standard error of statistics.
5. The effect of the level of confidence on the confidence interval is____.

What I Can Do

"Prove Me"

Give an example to prove that "increasing the confidence level will lead to a larger value of z".
Show your computations and give your conclusion.

	1 point	3 points	5 points	7 points	10 points
Description	Completely no understanding of the concept	Limited understanding of the concept, incorrect solutions	Demonstrate partial understanding with minor errors solutions.	Demonstrate understanding of the concept with correct solutions.	Demonstrate mastery of the concept, explain and justifies the correct solution.

Assessment

Read each item carefully. Write the letter that corresponds to the correct answer.

1. Which of the following shows confidence level?
   A. 80-96 B. 11.5 C. 1.9 D. 90%
2. Given: n = 40, μ= 9.7, σ= 6. Find the standard error of population mean ⌠.
   A. 0.93 B. 0.94 C. 0.95 D. 0.96

For **items 3-4,** refer to the given values in # 2.

3. Find the 95% confidence interval.
   A. [7.84,11.56] C. [8.84,12.56]
   B. [78.4,115.6] D. [88.4,125.6]
4. Find the 99% confidence interval
   A. [88.4,125.6] C. [7.05,12.04]
   B. [78.4,115.6] D. [7.25,12.14]
5. Given: The sampled population is normally distributed, n=60, $\overline{X}$ = 15.3, and σ^2 = 16. Find the 99% confidence interval for μ.
   A. [13.97,16.63] C. [11.97,12.63]
   B. [13.79,16.36] D. [11.79,12.36]

Additional Activities

Show your computation and round off your answer in 2 decimal places.

A sample of 50 Grade 11 students ‘age was obtained to estimate the mean age of all Grade 11 students. $\overline{X}$ = 17.2 years and the population variance is 16.

A. Find the critical value, standard error and margin of error.
B. Find the confidence interval using the 90% and 98% confidence level.
C. Identify the Lower confidence limit and upper confidence limit.
D. Solve and illustrate your answer in Normal Curve Distributions.
E. Make a conclusion.

LESSON 2: ESTIMATING THE CONFIDENCE INTERVAL FOR THE POPULATION MEAN WHEN σ IS UNKNOWN OR n < 30

What’s In

A. Determine whether the statement is true or false. Draw happy face if the statement is true and sad face if the statement is false before the number.

________1. The formula in determining the confidence interval for the population mean where the standard deviation is known is the sum of the point estimate and the margin of error.
________2. When the confidence level is 99%, α= 0.10.
________3. The margin of error is also known as sampling error.
________4. As the percentage of the confidence level is increasing the width of the interval estimate increases.
________5. If the alpha increased, the margin of error increased.
________6. The z- distribution table is used to determine the critical value when the population standard deviation is unknown.
________7. If you want to estimate the population mean with sample size exceeding 30 and the standard deviation is known, a conventional option is to find the critical value in the z-table.
________8. The $Z_{\frac{\alpha}{2}} = \pm 1.96$, if α = 0.10.
________9. With the standard error, low confidence level makes interval estimate wider.
_______10. The mean and the standard deviation of a normal curve distribution is 1 and 0.

What’s New

W.S. GOSSET aka "Student" (1876- 1937)

One of the most commonly used statistical method is the t- test. William S. Gosset discovered the formula for the t-distribution. Gosset graduated with honors in both mathematics and chemistry from Oxford University. At 23 years old he was hired by Guinness Brewery (the world's largest Brewery in Ireland) as a brewer chemist. As young brewers with other scientist they designed many field and lab experiments to determine the best barley, best hops, best temperatures for brewing, etc. He wrote and published his finding using pseudonym, "Student". Thus, the t- distribution is also called Student's t- distribution. As brewing employee, he was not allowed to publish results in his name.
Gosset remained at Guinness his whole career and continued statistical research, not only in brewery issues, but also in agricultural experimental design, and genetics. He died in October 1937 at the age of 61.

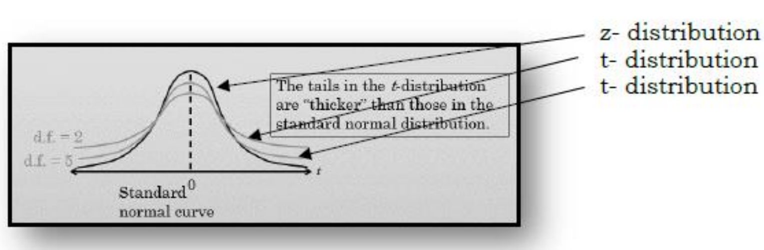
What is It

T – Distribution is also known as Student's t-distributions is the probability distribution that estimates the population parameters when

1. The population standard deviation σ is unknown and
2. The sample size is less than 30.

Properties of the *t*-distribution

1. The *t*-distribution is bell shaped and symmetric about the mean.
2. The *t*-distribution is a family of curves, each is determined by a parameter called the degrees of freedom. When you use a *t*-distribution to estimate a population mean, the degree of freedom is equal to one less than the sample size.
   d.f. = n – 1 Degree of freedom
3. The total area under a *t*-curve is 1 or 100%.
4. The mean, median, and mode of the *t*-distribution are equal to zero.
5. As the degrees of freedom increase, the *t*-distribution approaches the normal distribution. After 30 d.f., the *t*-distribution is very close to the standard normal *z*-distribution.



The t – Distribution Table

n	Degree of freedom (df = n-1)	Confidence Coefficient					
		0.50	0.80	0.90	0.95	0.98	0.99
	one tail	$t_{0.250}$	$t_{0.100}$	$t_{0.050}$	$t_{0.025}$	$t_{0.010}$	$t_{0.005}$
	two tails	$t_{0.500}$	$t_{0.200}$	$t_{0.100}$	$t_{0.050}$	$t_{0.020}$	$t_{0.010}$
2	1	1.000	3.078	6.134	12.706	31.821	63.657
3	2	0.816	1.886	2.920	4.303	6.965	9.925
4	3	0.765	1.638	2.353	3.182	4.541	5.841
5	4	0.741	1.533	2.132	2.776	3.747	4.604
6	5	0.727	1.476	2.015	2.571	3.365	4.032
7	6	0.718	1.440	1.943	2.447	3.143	3.707
8	7	0.711	1.415	1.895	2.365	2.998	3.499
9	8	0.706	1.397	1.860	2.306	2.896	3.355
10	9	0.703	1.383	1.833	2.262	2.821	3.250
11	10	0.700	1.372	1.812	2.228	2.764	3.169
12	11	0.697	1.363	1.796	2.201	2.718	3.106
13	12	0.695	1.356	1.782	2.179	2.681	3.055
14	13	0.694	1.350	1.771	2.160	2.650	3.012
15	14	0.692	1.345	1.761	2.145	2.624	2.977
16	15	0.691	1.341	1.753	2.131	2.602	2.947
17	16	0.690	1.337	1.746	2.120	2.583	2.921
18	17	0.689	1.333	1.740	2.110	2.567	2.898
19	18	0.688	1.330	1.734	2.101	2.552	2.878
20	19	0.688	1.328	1.729	2.093	2.539	2.861
21	20	0.687	1.325	1.725	2.086	2.528	2.845
22	21	0.686	1.323	1.721	2.080	2.518	2.831
23	22	0.686	1.321	1.717	2.074	2.508	2.819
24	23	0.685	1.319	1.714	2.069	2.500	2.807
25	24	0.685	1.318	1.711	2.064	2.492	2.797
26	25	0.684	1.316	1.708	2.060	2.485	2.787
27	26	0.684	1.315	1.706	2.056	2.479	2.779
28	27	0.684	1.314	1.703	2.052	2.473	2.771
29	28	0.683	1.313	1.701	2.048	2.467	2.763
30	29	0.683	1.311	1.699	2.045	2.462	2.756
inf.	∞	0.674	1.282	1.645	1.960	2.326	2.576

Illustrative examples:

1. Find the confidence coefficient
   a. n = 10, 99% confidence or 0.99
      answer: $df = n - 1$
      $df = 9,\ t_{\frac{\alpha}{2}} = 3.250$

n	Degree of freedom (df)	Confidence Coefficient					
		0.50	0.80	0.90	0.95	0.98	0.99
2	1	1.000	3.078	6.134	12.706	31.821	63.657
3	2	0.816	1.886	2.920	4.303	6.965	9.925
4	3	0.765	1.638	2.353	3.182	4.541	5.841
5	4	0.741	1.533	2.132	2.776	3.747	4.604
6	5	0.727	1.476	2.015	2.571	3.365	4.032
7	6	0.718	1.440	1.943	2.447	3.143	3.707
8	7	0.711	1.415	1.895	2.365	2.998	3.499
9	8	0.706	1.397	1.860	2.306	2.896	3.355
10	9	0.703	1.383	1.833	2.262	2.821	3.250

   b. n = 15, 90% confidence   answer: $df = 14,\ t_{\frac{\alpha}{2}} = 1.761$

n	Degree of freedom (df)	Confidence Coefficient (amount of α in two tails)					
		0.50	0.80	0.90	0.95	0.98	0.99
2	1	1.000	3.078	6.134	12.706	31.821	63.657
3	2	0.816	1.886	2.920	4.303	6.965	9.925
4	3	0.765	1.638	2.353	3.182	4.541	5.841
5	4	0.741	1.533	2.132	2.776	3.747	4.604
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9	8	0.706	1.397	1.860	2.306	2.896	3.355
10	9	0.703	1.383	1.833	2.262	2.821	3.250
11	10	0.700	1.372	1.812	2.228	2.764	3.169
12	11	0.697	1.363	1.796	2.201	2.718	3.106
13	12	0.695	1.356	1.782	2.179	2.681	3.055
14	13	0.694	1.350	1.771	2.160	2.650	3.012
15	14	0.692	1.345	1.761	2.145	2.624	2.977

2. Find the 2.5th percentile below and above of a t-distribution with 10 degrees of freedom.

Solution: 2.5% is the same as 0.025 in decimal, using the t-distribution table

n	Degree of freedom (df)	Confidence Coefficient					
		0.50	0.80	0.90	0.95	0.98	0.99
	one tail	$t_{0.250}$	$t_{0.100}$	$t_{0.050}$	$t_{0.025}$	$t_{0.010}$	$t_{0.005}$
	two tails	$t_{0.500}$	$t_{0.200}$	$t_{0.100}$	$t_{0.050}$	$t_{0.020}$	$t_{0.010}$
2	1	1.000	3.078	6.134	12.706	31.821	63.657
3	2	0.816	1.886	2.920	4.303	6.965	9.925
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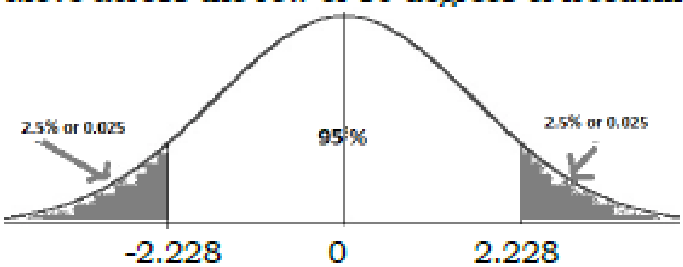
10	9	0.703	1.383	1.833	2.262	2.821	3.250
11	10	0.700	1.372	1.812	2.228	2.764	3.169

Move across the row of 10 degrees of freedom and find 0.025.



Therefore, the 2.5th percentile below and above of a t-distribution with 10 degrees of freedom are -2.228 and 2.228.

3. Find the 80th percentile between of a t- distribution with 5 degrees of freedom.

Solution: the above and below the 80% is 10% or 0.10, using the t-distribution table

n	Degree of freedom (df)	Confidence Coefficient					
		0.50	0.80	0.90	0.95	0.98	0.99
	one tail	$t_{0.250}$	$t_{0.100}$	$t_{0.050}$	$t_{0.025}$	$t_{0.010}$	$t_{0.005}$
	two tails	$t_{0.500}$	$t_{0.200}$	$t_{0.100}$	$t_{0.050}$	$t_{0.020}$	$t_{0.010}$
2	1	1.000	3.078	6.134	12.706	31.821	63.657
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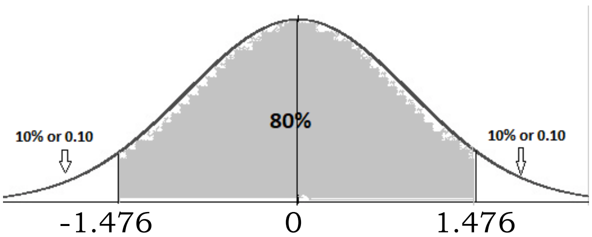
4	3	0.765	1.638	2.353	3.182	4.541	5.841
5	4	0.741	1.533	2.132	2.776	3.747	4.604
6	5	0.727	1.476	2.015	2.571	3.365	4.032



Therefore, the 80th percentile between of a t-distribution with 5 degrees of freedom are -1.476 and 1.476.

To express a confidence interval, you need three pieces of information.

a. If population standard deviation is unknown and the sample standard deviation (s) is estimated, especially when the sample size is small, substitute the sample standard deviation (s) in standard error $\left(\frac{s}{\sqrt{n}}\right)$.
b. The critical value also called confidence coefficient or called t- values found in the t-distribution table. In symbol, $\left(t_{\frac{\alpha}{2}}\right)$.
c. The degrees of freedom (df) the number of free choices left after a sample statistic has been computed. In symbol, (df)

Formulas:

Margin of error = Critical value x Standard error of the statistic

$$\boxed{E = t_{\frac{\alpha}{2}}\left(\frac{s}{\sqrt{n}}\right)}$$

Degree of freedom = sample size – 1

$$\boxed{df = n-1}$$

s- sample standard deviation

Formula for the Confidence Interval of the Mean for a Specific α

$$\overline{X} \pm t_{\frac{\alpha}{2}}\left(\frac{s}{\sqrt{n}}\right)$$

or

$$\overline{X} - t_{\frac{\alpha}{2}}\left(\frac{s}{\sqrt{n}}\right) < \mu < \overline{X} + t_{\frac{\alpha}{2}}\left(\frac{s}{\sqrt{n}}\right)$$

Where: $\overline{X}$ = Point of estimate
$t_{\frac{\alpha}{2}}$ = critical value
s = sample standard deviation
n = sample size

or

$$\overline{X} - E < \mu < \overline{X} + E$$

Confidence interval = sample statistic ± Margin of error

Illustrative Examples

1. Given: n= 20, $\overline{X}$ = 16 and s = 2, find the confidence interval of the true mean with 95% confidence.

Solution: $df = 19$, $t_{\frac{\alpha}{2}} = 2.093$

Confidence Interval: $\overline{X} - t_{\frac{\alpha}{2}}\left(\frac{s}{\sqrt{n}}\right) < \mu < \overline{X} + t_{\frac{\alpha}{2}}\left(\frac{s}{\sqrt{n}}\right)$

$$16 - (2.093)\left(\frac{2}{\sqrt{20}}\right) < \mu < 16 + (2.093)\left(\frac{2}{\sqrt{20}}\right)$$

$$\boxed{15.06 < \mu < 16.94}$$

Conclusion: We can say that the 95% confidence that the interval between 15.06 and 16.94 contains the true population mean.

2. The BPP/FBS students of SHS in MHS made a chocolate cake. The average weight of 25 chocolate bars selected from a normally distributed population is 200grams with sampled standard deviation of 10 grams. Find the interval estimate using the 95% confidence level.

Solution:

Given: n = 25, $df = 24$

s = 10, $\overline{X}$ = 200, 95% confidence $t_{\frac{\alpha}{2}} = 2.064$

Confidence Interval: $\overline{X} - t_{\frac{\alpha}{2}}\left(\frac{s}{\sqrt{n}}\right) < \mu < \overline{X} + t_{\frac{\alpha}{2}}\left(\frac{s}{\sqrt{n}}\right)$

$$200 - (2.064)\left(\frac{10}{\sqrt{25}}\right) < \mu < 200 + (2.064)\left(\frac{10}{\sqrt{25}}\right)$$

$$\boxed{195.87 < \mu < 204.13}$$

Conclusion: We can say that the 95% confidence that the interval between 195.87grams and 204.13 grams contains the true mean weight of chocolate bars.

What's More

Complete the table.

Given	df	$t_{\alpha/2}$	E	CI
1.n =15, $\bar{X}$= 50, s = 2.2, 95% CL	14		1.218	
2.n =25, $\bar{X}$= 55, s = 2.5, 90% CL		1.711		[54.14,55.86]
3.n =12, $\bar{X}$= 48.3, s = 4.3, 99% CL	11		3.855	
4.n =10, $\bar{X}$= 90.5, s = 2, 95% CL		2.262		[89.07,91.93]
5.n =22, $\bar{X}$= 65, s = 4.7, 80% CL	21		1.326	

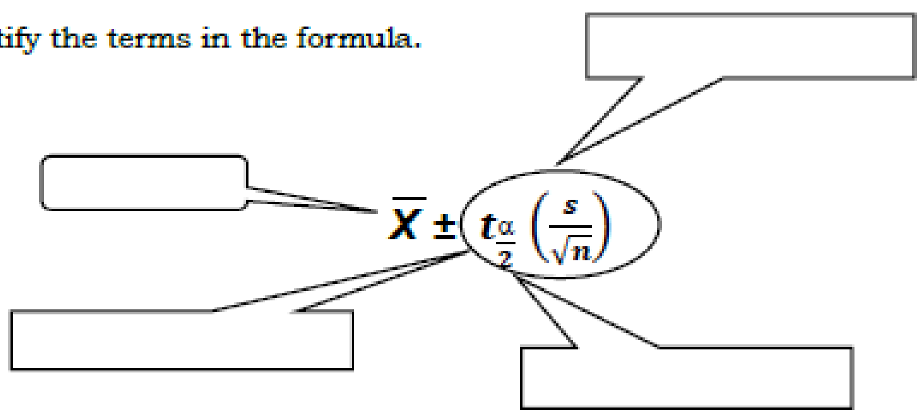
What I Have Learned

When to use the z or t distribution:

1. If____
2. If____

Confidence Interval/Interval Estimate formula (t- distribution)

Identify the terms in the formula.



What I Can Do

"Collect and Learn"

Collect 25 different coins (old and new) and identify the age of each coin. Compute the 95% confidence interval of the true mean age of the coins.

Recall the formula of standard deviation (s): s = $\sqrt{\frac{(X-X)^2}{n-1}}$

Solve the problem using UPS check.

Understand *Identify - What is the question?* *Rewrite the question in your own word*	**Plan** *Plan - What strategy will you use to solve the problem?* *What are the information needed to solve the problem?*
Solve *Solve - Carry out your plan* *Show all your thinking to solve the problem*	**-Check** *Verify - Does my answer make sense?* *Did you answer the questions that was asked? Explain*

	1 point	**3 points**	**5 points**	**7 points**	**10 points**
Description	Completely no understanding of the concept	Limited understanding of the concept, incorrect solutions	Demonstrate partial understanding with minor errors solutions.	Demonstrate understanding of the concept with correct solutions.	Demonstrate mastery of the concept, explain and justifies the correct solution.

Assessment

Carefully read the items below. Encircle the letter that corresponds to the exact answer.

1. Find the confidence interval when n = 25, X = 200, s = 10, CL = 95%.
   - A. [195.872, 204.128]
   - B. [204.128, 195.872]
   - C. [77.44, 87.55]
   - D. [77.45, 87.55]
2. What is the confidence coefficient of n = 24, 99% confidence?
   - A. 2.831
   - B. 2.819
   - C. 2.807
   - D. 2.797
3. A sample of 16 times of an easy assembled wallet of leather craft, SHS students yielded an average time of 19.92 minutes with a sample standard deviation of 5.73 minutes. Find the 95% confidence interval.
   - A. [16.8673, 22.9726]
   - B. [16.8672, 22.9726]
   - C. [16.8673, 22.9727]
   - D. [16.8672, 22.9727]
4. Find a 100(1 - α)% confidence interval for mean μ if $\bar{X}$ = 50, s = 5.03, n = 16, 〈= 0.01.
   - A. [46.290, 53.706]
   - B. [46.294, 53.706]
   - C. [46.290, 53.705]
   - D. [46.294, 53.705]
5. The mean age of 20 youth volunteers from SK in Concepcion I projects is 17.5 years with a standard deviation of 2 years. If the sample comes from an approximately normal distribution, what is the interval estimate of the population mean? Use 98% confidence level.
   - A. [16.37, 18.66]
   - B. [16.36, 18.66]
   - C. [16.37, 18.64]
   - D. [16.36, 18.64]

Additional Activities

Solve the following problems. Assume that all variables are normally distributed.

1. A sample of 25 person's walked, has an average of 6km per hour. The standard deviation for the sample was 1.2. Find the interval estimate of 95% confidence.

2. The results of a sample of randomly selected 8 SHS students Statistics and Probability test are 85, 83, 77, 68, 90, 75, 60, 93. Compute the 99% confidence interval of the true mean. Recall the formula of standard deviation (s): $s = \sqrt{\frac{(X-X)^2}{n-1}}$

LESSON 3: PROBLEMS INVOLVING SAMPLE SIZE BASED ON CONFIDENCE LEVEL

What's In

E

A. Evaluate each of the following.

1. $\left(\frac{(1.65)(1.3)}{0.3}\right)^2$
2. $\left(\frac{(2.33)(2.5)}{0.22}\right)^2$
3. $\left(\frac{(1.96)(1.2)}{0.62}\right)^2$
4. $\left(\frac{(2.58)(3.3)}{0.10}\right)^2$
5. $\left(\frac{(1.96)(3)}{0.5}\right)^2$

B. Read the situation below, then answer the questions that follow.

Last August 7, 2020, it is reported in the television that out of 119,460 cases of covid -19 in Philippines 56% recovered.

1. What does the report mean to you?
2. Can you determine the size of the sample to make an accurate estimate?

What's New

Consider the sample size formula from margin of error formula and the relation of sample size n and margin of error E.

Margin of Error: $E = Z_{\frac{\alpha}{2}}\left(\frac{\sigma}{\sqrt{n}}\right)$ CL: 95%, $Z_{\frac{\alpha}{2}} = 1.96$

ʃ = 5

Sample size (n) **30** **40** **50**

n increasing

$E = 1.96\left(\frac{5}{\sqrt{30}}\right)$ $E = 1.96\left(\frac{5}{\sqrt{40}}\right)$ $E = 1.96\left(\frac{5}{\sqrt{50}}\right)$

Margin of Error (E) **1.79** **1.55** **1.39**

E decreasing

Obviously, as the sample size n increases the margin of error E decreases. This is expected since n is the denominator. Larger sample size is more reliable and produces smaller error.

What is It

Deriving Formula

From

$$E = Z_{\frac{\alpha}{2}}\left(\frac{\sigma}{\sqrt{n}}\right)$$

or

$$E = \frac{Z_{\frac{\alpha}{2}}}{\sqrt{n}}$$

So,

$$E\sqrt{n} = Z_{\frac{\alpha}{2}}$$

$$\sqrt{n} = \frac{Z_{\frac{\alpha}{2}}}{E}$$

$$\left(\sqrt{n}\right)^2 = \left(\frac{Z_{\frac{\alpha}{2}}}{E}\right)^2$$

$$\boxed{n = \left(\frac{Z_{\frac{\alpha}{2}}}{E}\right)^2}$$

Therefore, the minimum sample size in estimating the sample mean is determined by the formula

$$\boxed{n = \left(\frac{Z_{\frac{\alpha}{2}}}{E}\right)^2}$$

From

$$E = Z_{\frac{\alpha}{2}}\sqrt{\frac{\hat{p}\,\hat{q}}{n}}$$

$$\frac{E}{Z_{\frac{\alpha}{2}}} = \sqrt{\frac{\hat{p}\,\hat{q}}{n}}$$

$$\left(\frac{E}{Z_{\frac{\alpha}{2}}}\right)^2 = \frac{\hat{p}\,\hat{q}}{n}$$

$$n \bullet E^2 = \hat{p}\hat{q} \bullet \left(Z_{\frac{\alpha}{2}}\right)^2$$

$$\boxed{n = \hat{p}\hat{q}\left(\frac{Z_{\frac{\alpha}{2}}}{E}\right)^2}$$

Therefore, the minimum sample size when estimating the population proportion is determined by the formula

$$\boxed{\mathbf{n} = \hat{p}\hat{q}\left(\frac{Z_{\frac{\alpha}{2}}}{E}\right)^2}$$

Where: n = sample size
$Z_{\frac{\alpha}{2}}$ = critical value
$\hat{p}$ = population proportions
$\hat{q}$ = (1- $\hat{p}$)
E = Margin of Error

Always round up to the next whole number when calculating sample size, no matter what the decimal value of your result is.
Example: a. 44.99 H 45 b. 462.25 H 463

Illustrative examples:

1. FBS teachers of MHS wants to estimate the mean weight ⌠ in kilogram of all grade 7 and grade 8 students to be included in a feeding program. She wants to be 99% confident that the estimate ⌠ is accurate to within 0.057 kg. Suppose from a previous study, the standard deviation of the weights of the target population was 0.53kg, what should the sample size be?

Solution*:* Using the formula in determining the minimum sample size,

$$n = \left(\frac{Z_{\frac{\alpha}{2}}}{E}\right)^2 \qquad 99\%\ CL,\ Z_{\frac{\alpha}{2}} = 2.58$$

$$n = \left(\frac{2.58\ \ 0.53}{0.057}\right)^2 \qquad E = 0.057$$

$$n = (23.99)^2$$

$$\boxed{\mathbf{n = 575.52}}$$

Round up the value to 575.52 to **576**. Therefore, the required sample size is 576 grade 7 and grade 8 students.

2. In a class experiment study, the lowest observed value is 13.7while the highest is 14.1. The population mean is estimated within an error of 0.028 of its true value. Using 99% confidence level, find the sample size n. (Note: In approximating the range R of observations in the population, estimate by H$\frac{R}{4}$.)

Solution:

Since the range R = 14.1 - 13.7 = 0.4, then ʃ $= \frac{R}{4} = \frac{0.4}{4} = 0.1$

$$n = \left(\frac{Z_{\frac{\alpha}{2}}}{E}\right)^2 \qquad 99\% \text{ CL, } Z_{\frac{\alpha}{2}} = 2.58$$

$$n = \left(\frac{2.58\ \ 0.1}{0.028}\right)^2 \qquad E = 0.028$$

$$n = (9.21)^2$$

$$\boxed{\mathbf{n = 84.82}}$$

Round up the value 84.82 to **85**. Therefore, the required sample size is 85.

3. With 95% confidence, Frits wants to know the proportion of teenagers who like milk tea. A previous study showed that 33% like milk tea. Fritz likes to be accurate within 3% of the true population. What sample size does he need?

   Solution: From

$$n = \hat{p}\hat{q}\left(\frac{Z_{\frac{\alpha}{2}}}{E}\right)^2$$

$$n = (0.33)(0.67)\left(\frac{1.96}{0.03}\right)^2 \qquad , \hat{p} = 0.33,\ \hat{q} = (1-\hat{p}) = 0.67$$

$$n = (0.33)(0.67)(4268) \qquad E = 3\% = 0.03$$

$$\boxed{\mathbf{n = 943.65}} \qquad 95\%\text{CL } Z_{\frac{\alpha}{2}} = 1.96$$

Rounding up 943.65 to whole number is 944. Therefore, the required sample size is 944 respondents.

What's More

Give what are asked for.

Assumed all the variable are approximately normally distributed. Round up to the next whole number.

1. Find the sample size for each of the following
   a. 85% confidence, E = 0.08, $\hat{p}$ = 0.6
   b. 98% confidence, E = 0.13, $\hat{p}$ = 0.62

c. 96% confidence, E = 0.06, $\hat{p}$= 0.23

2. PLDT telecom wants to estimate the number of household's usage of internet in one week for their business plan and model. The sample mean is within 1 minute of the population mean in 95% confidence. The previous standard deviation survey of household was 6.75 minutes. How many households used internet in one week for the PLDT telecom business plan model?

What I Have Learned

Answer ME:

1. What will happen to the maximum error of estimate if the number of sample increases?

   ____

2. What is the part of population that is included in the study to make inference of the population?

   ____

3. The formula in finding the minimum sample size is derived from____________.
4. How do you find a sample size in estimating the population mean?

   ____

5. How do you find a sample size in estimating the population proportion?

   ____

What I Can Do

“Fill Me”

Suppose you want to know the ____% confidence of the proportion of SHS students who like tiktok. And suppose a previous survey showed that ___% like tiktok. You like to be accurate within 2% of the true proportion. What sample size do you need?

C Circle the given in the problem.

U Underline the Question asked.

B Box the math action word.

E Evaluate what steps you should take to solve the problem.

S Solve and check.

	1 point	3 points	5 points	7 points	10 points
Description	Completely no understanding of the concept	Limited understanding of the concept, incorrect solutions	Demonstrate partial understanding with minor errors solutions.	Demonstrate understanding of the concept with correct solutions.	Demonstrate mastery of the concept, explain and justifies the correct solution.

Assessment

Read each item below then write the letter that corresponds to the correct answer.

1. It is a part of the population in the study to make inference of the population.
   A. sample size
   B. critical value
   C. population size
   D. confidence interval

2. It expresses the maximum expected difference between the true population parameter and a sample estimate of that parameter.
   A. confidence interval
   B. critical value
   C. confidence level
   D. margin of error

3. Which of the following shows confidence level?
   A. 80-96
   B. 11.5
   C. 90%
   D. 1.9

4. What is the critical coefficient that correspond to an area of 0.4495?
   A. 2.75
   B. 2.58
   C. 1.96
   D. 1.64

5. A range of values that is used to estimate a parameter.
   A. sample size
   B. critical value
   C. population size
   D. confidence interval

Additional Activities

Solve for the following problem. Assume that all variables are normally distributed.

1. Jomari wants to investigate a particular brand of milk tea that contains an average of 85mg of caffeine per glass with standard deviation of 15mg. The estimate caffeine content correct in the true population mean is within 3 mg adopting 95% confidence. How many glasses of milk tea does he need for a sample?
2. If the standard deviation of the computer lifetimes is estimated as 100 hours, how large a sample of measurement must be selected in order to be 90% confident that the error in the estimated mean lifetime will not exceed 20 hours?
3. From your own constructed problem in What I Can Do part, use the following data to find the sample size in estimating the population proportion:
E = 2%, 90%Confidence, $\hat{p}$ = 37% .

SUMMATIVE TEST

Read and analyze each item. Then write the letter of the correct answer.

1. Which of the following is not mentioned in the computation for the confidence interval estimate if standard deviation is known?
   A. $\frac{\alpha}{2}$ C. margin of error
   B. confidence level D. t- level
2. On what step of the computation of the confidence interval estimate the critical value and standard error are multiplied?
   A. First step C. Third step
   B. Second step D. Fourth step
3. Which of the following is not included in finding the critical value in the computation for the confidence interval estimate?
   A. confidence interval C. degrees of freedom
   B. confidence level D. alpha level
4. The number of customers per day in a computer shop was recorded and has a standard deviation of 5 customers. 37 are randomly selected and produced a mean of 35 customers. With a confidence level of 98%, find the value of $Z_{\frac{\alpha}{2}}$.
   A. 2.31 B. 2.33 C. 2.55 D. 2.58
5. Find the margin of error in item 4.
   A. 1.91 B. 1.92 C. 1.93 D. 1.94

6. Find the minimum sample size in estimating the population proportion where E = 0.03, $\hat{p}$ = 0.45 with 95% confidence.

A.1056 B. 1057 C. 1058 D. 1059

7. Which of the following symbols denotes margin of error?
A. μ B. ʃ C. E D. X

8. The formula for finding the confidence interval is __________.
A. $Z_{\frac{\alpha}{2}}$ B. $\frac{\sigma}{\sqrt{n}}$ C. $\pm Z_{\frac{\alpha}{2}}\left(\frac{\sigma}{\sqrt{n}}\right)$ D. $\overline{X} \pm Z_{\frac{\alpha}{2}}\left(\frac{\sigma}{\sqrt{n}}\right)$

9. Scores on an examination in Statistics and Probability are normally distributed with a population standard deviation of 5.6. A random sample of 40 scores on the exam has a mean of 32. Find the 80% Confidence interval.
A. [30.87,33.13] C. [30.54,33.46]
B. [29.94,34.06] D. [29.54,34.46]

10. In #9, what is the standard of error?
A. 0.89 B. 0.88 C. 0.87 D. 0.86

11. Given: n = 22, X = 76.5, s = 2.1. Identify the point estimate of the population mean.
A. 2.1 B. 22 C. 76.5 D. none of these

12. From # 11, find the lower and upper limits using 80% confidence.
A. [75.90,77.09] C. [75.90, 77.10]
B. [75.91,77.10] D. [75.91,77.09]

13. What is the appropriate distribution, if n < 30 and the population standard deviation is unknown?
A. E B. $\bar{X}$ C. t D. z

14. A process of making conclusions about parameters in the population from sample.
A. descriptive statistics C. inferential statistics
B. parameter D. sample

15. When n = 18 and α = 0.01, the critical value is __________.
A. 2.898 B. 2.878 C. 1.740 D. 1.734

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Answer Key

Conclusion: With 98% confidence that the interval approximately between 15.88 and 18.52 age contain the population mean μ based on Grade 11 students age

LESSON 2: ANSWER KEY

Assessment

1. A
2. C
3. C
4. B
5. D

What's in ☺ ☹

1.	☹	6.	☹
2.	☹	7.	☺
3.	☺	8.	☹
4.	☺	9.	☹
5.	☹	10.	☹

What More

A.

Given	df	$t_{\alpha/2}$	E	CI
1.n =15, $\overline{X}$= 50, s = 2.2, 95% CL	14	2.145	1.218	[48.78,51.22]
2.n =25, $\overline{X}$= 55, s = 2.5, 90% CL	24	1.711	0.856	[54.14,55.86]
3.n =12, $\overline{X}$= 48.3, s = 4.3, 99% CL	11	3.106	3.855	[44.45,52.16]
4.n =10, $\overline{X}$= 90.5, s = 2, 95% CL	9	2.262	1.431	[89.07,91.93]
5.n =22, $\overline{X}$= 65, s = 4.7, 80% CL	21	1.323	1.326	[63.67,66.33]

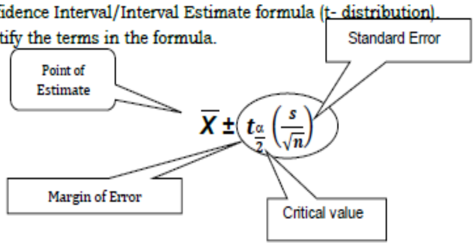
What I Have Learned

When to use the z or t distribution:

1. If the σ is known or n ≥ 30, use z- distribution table.
2. If the σ is known and n < 30, use t- distribution table.

Confidence Interval/Interval Estimate formula (t- distribution).

Identify the terms in the formula.



Additional Activity

Confidence Interval: $\overline{X} - t_{\frac{\alpha}{2}}\left(\frac{s}{\sqrt{n}}\right) < \mu < \overline{X} + t_{\frac{\alpha}{2}}\left(\frac{s}{\sqrt{n}}\right)$

$$6 - (2.064)\left(\frac{1.2}{\sqrt{25}}\right) < \mu < 6 + (2.064)\left(\frac{1.2}{\sqrt{25}}\right)$$

$$\boxed{5.50 < \mu < 6.50}$$

onclusion: We can say that the 95% confidence that the interval between 50km and 6.50km contains the true mean a person walked in an hour.

2. Given: X = {85,83,77,68,90,75,60,93}

n = 8 df = 7

$$\overline{X} = \frac{\Sigma X}{n} = 78.88$$

$$s = \sqrt{\frac{\Sigma(X-\overline{X})^2}{n-1}} = 11.15$$

CL = 99% $t_{\frac{\alpha}{2}} = 3.499$

Confidence Interval: $\overline{X} - t_{\frac{\alpha}{2}}\left(\frac{s}{\sqrt{n}}\right) < \mu < \overline{X} + t_{\frac{\alpha}{2}}\left(\frac{s}{\sqrt{n}}\right)$

$$78.88 - (3.499)\left(\frac{11.15}{\sqrt{8}}\right) < \mu < 78.88 + (3.499)\left(\frac{11.15}{\sqrt{8}}\right)$$

$$\boxed{65.09 < \mu < 92.67}$$

onclusion: We can say that the 99% confidence that the interval between 5.09 and 92.67contains the true mean of the test results.

ESSON 3: ANSWER KEY

ssessment

1. A
2. A
3. C
4. D
5. D

hat's in

1. 51.12	B. 6. 1.65
2. 701.05	7. 2.33
3. 14.39	8. 1.44
4. 7248.82	9. 1.28
5. 138.30	10. 1.75

hat More

1. Round up
   a. 1.17 ≈ 2
   b. 75.68 ≈ 76
   c. 206.74 ≈ 207
2. 175.03 ≈ 176 (approximately 176 households)

hat I Have Learned

Answer ME:

1. Decreases
2. Sample size
3. Margin of error
4. Round up
5. 1.65, 1.96, 2.58
6. Sample size is important to the study in which the goal is to make inferences about a population.
7. Just substitute the given values to the formula in finding the sample size for population proportion.
8. Just substitute the given values to the formula in finding the sample size for population proportion.

Additional Activity

1. 96.04 ≈ 97 (approximately 97 glasses of milk tea)
2. 68.06 ≈ 69 (approximately 69 computers)
3. 1586.84 ≈ 1587 (approximately 1587)

Summative test

1.D	9. A
2.C	10.A
3.A	11.C
4.B	12.D
5.B	13.C
6.B	14.C
7.C	15.A
8.D	

LESSON1: ANSWER KEY

Pre-test

1. B	6. A	11.D	
2. A	7. B	12.D	
3. B	8. C	13.B	
4. D	9. B	14.A	
5. D	10. B	15.B	

Assessment

1.D
2.C
3.A
4.D
5.A

What's In

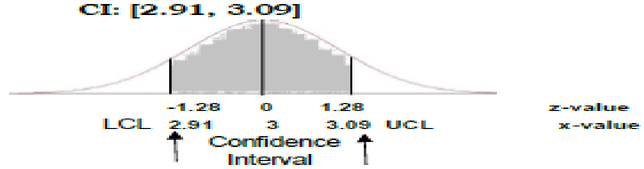
1. a. 1.65, b. 1.96, c. 2.58, d. 2.33, e. 1.28
2. Normal Curve Distributions
3. Standard of Error
4. 0, 1
5. 1.64

What More

1. a. 1.28, 7.07, ±0.09
   b. (2.91, 3.09)
   c. LL: 2.91   UL: 3.09
   d. Confidence Interval: $\overline{X} \pm Z_{\frac{\alpha}{2}} \left(\frac{\sigma}{\sqrt{n}}\right)$ where: $n = 50$, $\sigma = 0.5$

$= 17.2 \pm 1.28\left(\frac{0.5}{\sqrt{50}}\right)$ CL: 80%, $Z_{\frac{\alpha}{2}} = \pm 1.28$

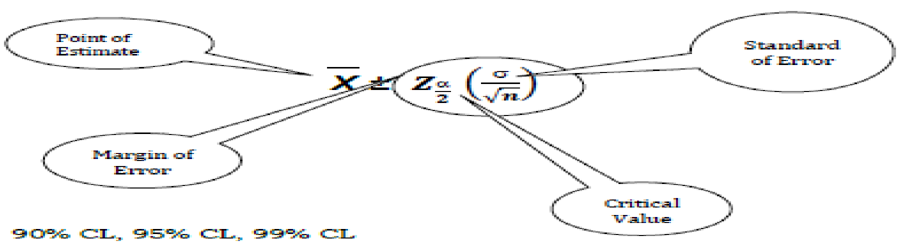
CI: [2.91, 3.09]



e. Conclusion: With 80% confidence that the interval approximately between 2.91 hours and 3.09 hours contain the population mean μ based on SHS students practicing "Taga Marikina Ako" dance.

What I Have Learned

1.



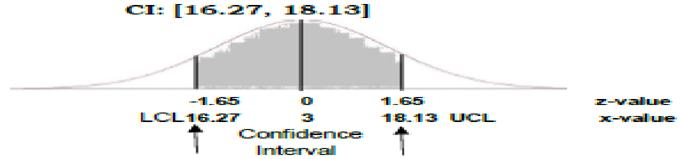
2. 90% CL, 95% CL, 99% CL
3. Select confidence level
4. Confidence Interval
5. Margin of Error
6. As the level of confidence increasing the length of the confidence interval wider.

Additional activity

a. Confidence Interval: $\overline{X} \pm Z_{\frac{\alpha}{2}} \left(\frac{\sigma}{\sqrt{n}}\right)$

$= 17.2 \pm 1.65\left(\frac{4}{\sqrt{50}}\right)$ CL: 90%, $Z_{\frac{\alpha}{2}} = \pm 1.65$

CI: [16.27, 18.13]

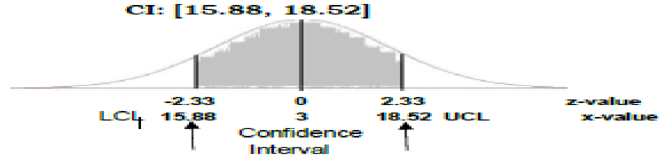


Conclusion: With 90% confidence that the interval approximately between 16.27 and 18.13 age contain the population mean μ based on Grade 11 students age.

b. Confidence Interval: $\overline{X} \pm Z_{\frac{\alpha}{2}} \left(\frac{\sigma}{\sqrt{n}}\right)$

$= 17.2 \pm 2.33\left(\frac{4}{\sqrt{50}}\right)$ CL: 98%, $Z_{\frac{\alpha}{2}} = \pm 2.33$

CI: [15.88, 18.52]



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