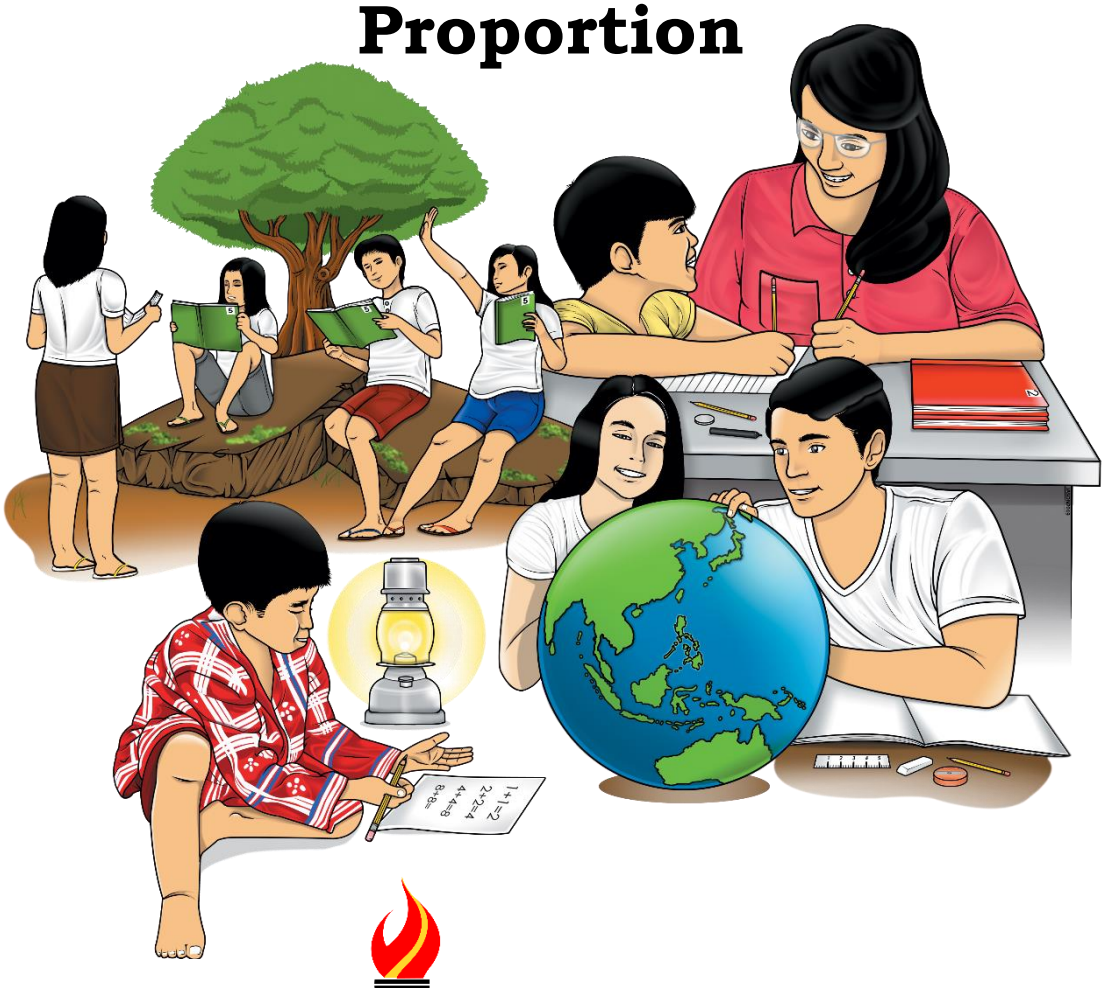
Senior High School

DepED
DEPARTMENT OF EDUCATION

Statistics and Probability

Quarter 4 – Module 14: Solving Problems Involving Test of Hypothesis on Population Proportion



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Senior High School

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Quarter 4 – Module 14:

Solving Problems Involving Test of Hypothesis on Population Proportion

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Introductory Message

This Self-Learning Module (SLM) is prepared so that you, our dear learners, can continue your studies and learn while at home. Activities, questions, directions, exercises, and discussions are carefully stated for you to understand each lesson.

Each SLM is composed of different parts. Each part shall guide you step-by-step as you discover and understand the lesson prepared for you.

Pre-tests are provided to measure your prior knowledge on lessons in each SLM. This will tell you if you need to proceed on completing this module or if you need to ask your facilitator or your teacher's assistance for better understanding of the lesson. At the end of each module, you need to answer the post-test to self-check your learning. Answer keys are provided for each activity and test. We trust that you will be honest in using these.

In addition to the material in the main text, Notes to the Teacher are also provided to our facilitators and parents for strategies and reminders on how they can best help you on your home-based learning.

Please use this module with care. Do not put unnecessary marks on any part of this SLM. Use a separate sheet of paper in answering the exercises and tests. And read the instructions carefully before performing each task.

If you have any questions in using this SLM or any difficulty in answering the tasks in this module, do not hesitate to consult your teacher or facilitator.

Thank you.

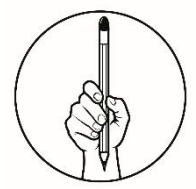
What I Need to Know

In real life whenever we are confronted with problems, our decision-making skill is being tested. Before we decide, there are certain considerations and analysis of the given conditions must be made. Someone can be an expert problem solver if s/he is able to apply the learned concepts in a particular situation. Although problem solving has steps, someone may have his/her own way or techniques of solving a problem.

Meanwhile, in statistical analysis, there are steps that need to be followed in solving problems involving test of hypothesis on population proportion. The objective is for us to make a correct decision about the null hypothesis. It is whether we can confidently say that the change in our data is real, definite, and not attributed by chance.

After going through this module, you are expected to:

1. enumerate the steps in solving problems involving test of hypothesis on population proportion; and
2. solve problems involving test of hypothesis on the population proportion.



What I Know

Choose the letter of the best answer. Write the chosen letter on a separate sheet of paper.

1. Supposing that in a certain research conducted about the number of students who prefer using cell phones rather than reading books, it was found out that 85% of the students preferred not to read. On the following year, the same study was conducted with 120 out of 150 randomly selected students having the same preference. It was found out that there was an increase in number. Test the claim at $\alpha = 0.01$.
   Which of the following would be an appropriate alternative hypothesis?
   a. The sample proportion is less than 0.85.
   b. The sample proportion is no less than 0.85.
   c. The population proportion is less than 0.85.
   d. The population proportion is no less than 0.85.

2. In problem no. 1, which of the following would be the null hypothesis?
   a. The sample proportion is 0.85.
   b. The population proportion is 0.85.
   c. The sample proportion is not equal to 0.85.
   d. The population proportion is not equal to 0.85.

3. A Type I error is committed when _____.
   a. we reject a null hypothesis that is true
   b. we reject a null hypothesis that is false
   c. we don't reject a null hypothesis that is true
   d. we don't reject a null hypothesis that is false

4. In testing hypotheses, which of the following would be a strong evidence against the null hypothesis?
   a. using small number of samples
   b. using a high level of significance
   c. obtaining data with a small p-value
   d. obtaining data with a low test statistic

5. What is the critical value (in a test about proportions) for a left-tailed test with $\alpha = 0.05$ and $n \geq 30$?
   a. $z_{com} = -2.33$
   b. $z_{com} = -1.96$
   c. $z_{com} = -1.645$
   d. $z_{com} = 2.58$

6. Suppose the p-value for a hypothesis test is 0.0304. Using $\alpha = 0.05$, what is the appropriate conclusion?
   a. Reject the null hypothesis.
   b. Fail to reject the null hypothesis.
   c. Reject the alternative hypothesis.
   d. Accept the alternative hypothesis.

7. When p-value is less than the alpha, we _____.
   a. reject H_o
   b. reject H_a
   c. accept H_a
   d. fail to reject H_o

8. Tina wants to know if the proportion of people who buy *suman* is affected at all by her open microphone reading. If p=0.8 before her reading, what is the appropriate set of hypotheses?

   a. H_o: $p = 0.8$
      H_a: $p > 0.8$

   b. H_o: $p = 0.8$
      H_a: $p < 0.8$

   c. H_o: $p \neq 0.8$
      H_a: $p = 0.8$

   d. H_o: $p = 0.8$
      H_a: $p \neq 0.8$

9. In a research report, the results of a hypothesis test include the expression "z=3.15, p < 0.01". This means that the test should _____.
   a. reject the null hypothesis
   b. reject the alternative hypothesis
   c. fail to reject the null hypothesis
   d. fail to reject the alternative hypothesis

10. In problem no. 9, what is the level of significance used?
    a. $\alpha = 0.5$ b. $\alpha = 0.1$ c. $\alpha = 0.05$ d. $\alpha = 0.01$

For nos. 11-15, refer to the given problem below.

It was claimed that on a certain year, 55% of Filipinos believed that there was an improvement in the Philippine economy. Suppose that on the following year, only 290 out of 500 people randomly selected believed that there was an improvement in our country's economy. Does this indicate an ***increase*** in the number of certain Filipinos who believed that there was an improvement in our economy? Use 0.05 level of significance.

11. What is the appropriate alternative hypothesis to be used?
    a. $H_a : p < p_o$
    b. $H_a : p > p_o$
    c. $H_a : p \neq p_o$
    d. $H_a : p = p_o$

12. What is the value of α?
    a. 0.55 b. 0.50 c. 0.05 d. 0.01

13. What is the value of $\hat{p}$?
    a. 0.55 b. 0.58 c. 0.65 d. 0.725

14. What is the critical z-value to be used?
    a. 1.645 b. 2.00 c. 2.58 d. 2 .96

15. Which of the following is the best decision and conclusion based on the results of the test statistic? ***The computed z-statistic or z_{com} is 1.35.***
    a. Since the computed test statistic z_{com} = 1.35 does not fall in the rejection region, ***do not reject*** the null hypothesis. Therefore, we conclude that at 0.05 level of significance, there was not enough evidence that the number of people who believed that there was an improvement in our economy has increased.
    b. Since the computed test statistic z = 1.35 does not fall in the rejection region, ***reject*** the null hypothesis. Therefore, we conclude that at 0.05 level of significance, there was not enough evidence that the number of people who believed that there was an improvement in our economy has increased.
    c. Since the computed test statistic z = 1.35 falls on the rejection region, ***do not reject*** the null hypothesis. Therefore, we conclude that at 0.05 level of significance, there was enough evidence that the number of people who believed that there was an improvement in our economy has increased.
    d. Since the computed test statistic z = 1.35 does not fall in the rejection region, ***do not reject*** the null hypothesis. Therefore, we conclude that at 0.05 level of significance, there was enough evidence that the number of people who believed that there was an improvement in our economy has increased.

Lesson 1 Solving Problems Involving Test of Hypothesis on Population Proportion

What's In

Activity 1: Give Your Best!

Read, analyze, and identify the given on the following problems involving population proportions.

1. It has been claimed that 30% of students in a particular senior high school dislike Mathematics. When a survey was conducted by a researcher, it showed that 150 of 1,000 students dislike Mathematics. Test if the claim was ***different*** from the population at $\alpha = 0.01$ level.

   Given:

   a. H_o : _____(symbols)

      _____(statement)

   b. H_a : _____(symbols)

      _____(statement)

   c. Level of Significance = _____

   d. n = _____

   e. X = _____

   f. $\hat{p}$ = _____

2. In a public senior high school, a survey conducted last year by the barangay health workers showed that 10% of the students drink alcohol. This year, a new survey was conducted randomly on 320 students from the same school and it was found out that 28 of them drink alcohol. Determine if the claim that there is a decrease on the proportion of senior high school students who drink alcohol is true. Use $\alpha = 0.05$.

   Given:

   a. H_o : _____(symbols)

      _____(statement)

   b. H_a : _____(symbols)

      _____(statement)

   c. Level of Significance = _____

   d. n = _____

   e. X= _____

   f. $\hat{p}$ = _____

What's New

Below is a problem with its solutions/answers already given. Arrange the steps by writing numbers ***1-5*** based on your understanding on the proper order of solving problems on population proportions.

PROBLEM:

A research study was conducted to determine the number of students who watch news on national television during weekdays. The percentage of those watching was 15%. The next school year, the same study was conducted among randomly selected students. It was found out that the number of students watching news was lower than the previous year. Test the claim at $\alpha = 0.05$.

_____ **DECISION:** Does not fall in the rejection region; fail to reject the H_o

_____ computed *z*-statistic: $z_{com} = -1.15$ and critical *z*-value: -1.645

_____ H_o: The proportion of students who watch news in national TV during weekdays is 15%. (H_o : $p = 0.15$)

H_a : The proportion of students who watch news in national TV during weekdays is fewer than 15%. (H_o : $p < 0.15$)

_____ **CONCLUSION:** Therefore, we conclude that at 0.05 level of significance, there was insufficient evidence to claim that the proportion of students who watch news in national TV during weekdays is lower than 15%.

_____ $\alpha = 0.05$ level of significance

What is It

Just like in puzzles, you need to think of different ways on how you will be able to solve it. Same with solving problems involving test of hypotheses on population proportions, you need to follow important steps in order to arrive at the correct answer.

Here are the five (5) steps in solving problems for a test of hypothesis on the population proportion.

STEP 1. **HYPOTHESES:** State the null and alternative hypotheses (either in sentence/statement form or in symbols)

$\mathbf{H_o}$: $p = p_o$

$\mathbf{H_a}$: $p < p_o$ **or** $\mathbf{H_a}$: $p > p_o$ **or** $\mathbf{H_a}$: $p \neq p_o$

STEP 2. **LEVEL OF SIGNIFICANCE *(α)*:** Choose a level of significance like $\alpha = 0.01$ level.

STEP 3. **TEST STATISTIC:** Calculate the appropriate test statistic.

Remember:

Test statistic is a random variable calculated from a sample. You can use test statistics to determine whether to reject the null hypothesis or not. The test statistic compares your data with what is expected under the null hypothesis. The test statistic is used to calculate the p-value.

A test statistic measures the degree of agreement between a sample of data and the null hypothesis. Its observed value changes randomly from one random sample to a different sample. A test statistic contains information about the data relevant on deciding whether to reject the null hypothesis or not.

STEP 4. CRITICAL VALUE/P-VALUE: Determine the critical value or p-value.

$$\hat{p} = \frac{x}{n} \qquad z = \frac{\hat{p}-p}{\sqrt{\frac{pq}{n}}} \quad \text{or} \quad z = \frac{\hat{p}-p}{\sqrt{\frac{p(1-p)}{n}}}$$

where: x = *number of sample units that possess the characteristics of interest*

p = *population proportion* $\qquad q = 1 - p$

$\hat{p}$ = *sample proportion* $\qquad n$ = *sample size*

Remember:

The critical value and p-value are the points being compared with the test statistic in order to make the final decision on whether to reject the null hypothesis or not.

STEP 5. **DECISION/CONCLUSION:**

- The decision will be either to reject or fail to reject the null hypothesis (H_o).
- Draw your conclusion about the population proportion based on the test statistic value and the rejection region.
  - If the computed z-statistic (z_{com}) is > or < the tabular/critical value (z_{tab}), ***reject*** the null hypothesis (H_o).
  - If the computed z-statistic(z_{com}) falls in the rejection region, ***reject*** the null hypothesis (H_o).
  - If the computed z-statistic(z_{com}) does not fall in the rejection region, ***fail to reject*** the null hypothesis (H_o).

NOTE:

(These conditions were already mentioned in the previous module on drawing conclusions on population proportions.)

> To solve problems involving population proportions, just follow the 5-step procedure mentioned above.

Illustrative Examples

Example 1: Every year, the assigned teachers determine the Body Mass Index (BMI) of students. In a certain public junior high school, a study finds that 10% of Grade 7 students observed are underweight. A sample of 780 Grade 7 students were randomly chosen and it was found out that 125 of them are underweight. Is this claim different for their grade level age? Use 0.05 level of significance.

SOLUTION:

STEP 1: State the null and alternative hypotheses.

H_o ; $p = 0.10$

H_a : $p \neq 0.10$

STEP 2: Choose a level of significance. $\alpha = 0.05$

STEP 3: Compute the test statistic.

Given: x = 125 p = 0.10 n = 780

$$\hat{p} = \frac{X}{n}$$

$$= \frac{125}{780}$$

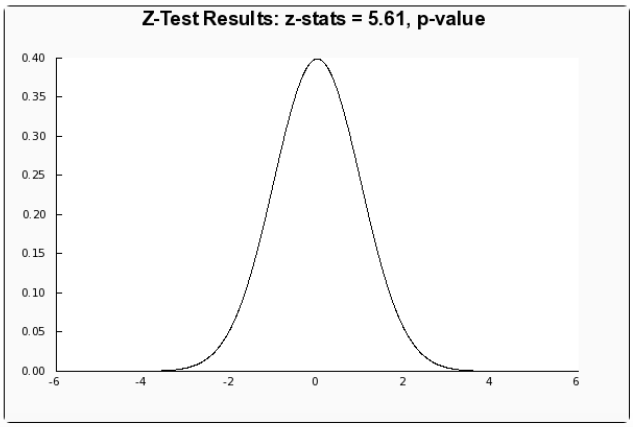
$$\hat{p} = 0.16$$

$$z = \frac{\hat{p} - p}{\sqrt{\frac{p(1-p)}{n}}}$$

$$= \frac{0.16 - 0.10}{\sqrt{\frac{0.10\,(1-0.10)}{780}}}$$

$$= \frac{0.06}{0.01}$$

$$z_{com} = 6.0$$



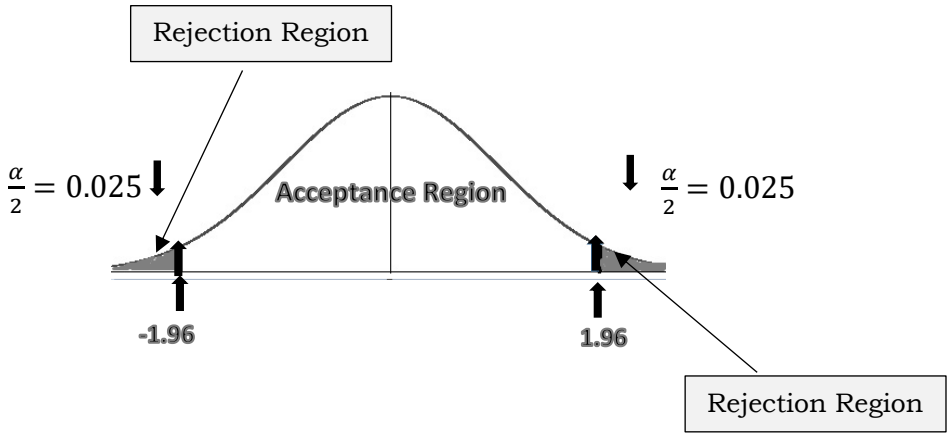
STEP 4: Determine the critical value.

> **NOTE**: Since the alternative hypothesis is ***non-directional***, the two-tailed test shall be used. Divide ***a*** by 2, then subtract the quotient from 0.05.

$$\frac{\alpha}{2} = \frac{0.05}{2} = 0.025$$

Therefore, 0.05 – 0.025 = 0.025.

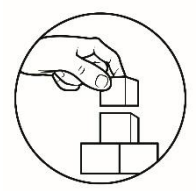
> **NOTE**: Using the Areas Under the Normal Curve Table, $\frac{\alpha}{2}$ critical *values* at 0.05 level of significance are $\pm$ ***1.96***



STEP 5: Make a decision whether to <u>reject</u> or <u>fail to reject</u> the null hypothesis. Draw a conclusion.

DECISION: Since the computed test statistic z_{com} = 6.0 ***is greater than the critical value*** or ***it falls in the rejection region***, ***<u>reject</u>*** *the null hypothesis.*

CONCLUSION: Therefore, we conclude that at 0.05 level of significance, ***there is enough evidence*** that the percentage of Grade 7 students who are underweight is different from 10%.



What's More

Make Your Own

Using the given set of values/parts of the test of hypothesis involving population proportions, construct your own word problem about the specified topic in each number.

1. $\alpha = 0.05$
   Ho: $p = 0.6$
   Ha: $p \neq 0.6$

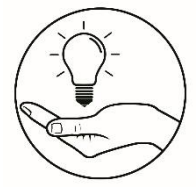
   TOPIC: Numeracy rate of a certain high school

2. $\alpha = 0.05$
   $p = 0.45$
   right-tailed test

   TOPIC: Number of tourists at a certain landmark in the Philippines

3. Population proportion is 0.85.
   non-directional test

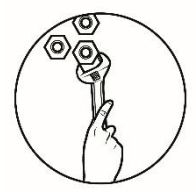
   TOPIC: Spread of virus/bacteria



What I Have Learned

In order to solve problems involving test of hypotheses on population proportion, the five (5) steps are:

1. _____
2. _____
3. _____
4. _____
5. _____



What I Can Do

A. Give three (3) best experiences in your life wherein you think you made the right decisions. Share some things, ideas, or techniques that you considered before finally deciding. You are going to present your answers through a collage in a short bond paper. (Use recyclable materials like old magazines, newspaper, etc.)

B. In a 5-sentence paragraph, give reasons why you should be a wise decision maker and why you should have good problem-solving skills.

Assessment

Multiple Choice. Choose the letter of the best answer. Write the chosen letter on a separate sheet of paper.

1. A hypothesis test is done in which the alternative hypothesis is that more than 10% of the population is left-handed. The calculated p-value for the test is 0.25. Which statement is correct?
    a. We can conclude that exactly 25% of the population is left-handed.
    b. We can conclude that more than 10% of the population is left-handed.
    c. We can conclude that more than 25% of the population is left-handed.
    d. We cannot conclude that more than 10% of the population is left-handed.

2. In a nationwide survey, 1,500 adults were asked about attitudes toward "alternative medicine" such as acupuncture, massage therapy, etc. Among the 1,500 respondents, 660 said they would use alternative medicine if the traditional medicine did not produce the results they wanted. The researcher wants to determine if these data provide enough evidence to suggest that less than half of all adults would use alternative medicine if traditional medicine didn't produce the desired results. The level of significance used was 5%. Which is the correct conclusion for this test?
    a. Since p-value = 0.001 < 0.05, I reject Ho. There is enough evidence to suggest that the proportion is less than half.
    b. Since p-value = 0.001 < 0.05, I fail to reject Ho. There is not enough evidence to suggest that the proportion is less than half.

c. Since p-value = 0.001 > 0.05, I reject Ho. There is enough evidence to suggest that the proportion is less than half.
d. Since p-value = 0.001 < 0.05, I fail to reject Ho. There is enough evidence to suggest that the proportion is less than half.

3. A potato chip producer and a supplier of potatoes agree that each shipment must meet certain quality standards. If the producer is convinced that more than 8% of the potatoes in the shipment have blemishes, the truck will be sent away and another one would have to be sent. In a recent shipment, an SRS of 80 potatoes was selected and 7 had blemishes. Use $\alpha = 0.01$.
Which is the correct decision for this test?
   a. Since p-value = 0.4024 > .01, I reject H_0.
   b. Since p-value = 0.4024 > .01, I reject H_0.
   c. Since p-value = 0.4024 < .01, I fail to reject H_0.
   d. Since p-value = 0.4024 > .01, I fail to reject H_0.

4. In problem no. 3, what will be the correct conclusion regarding the claim?
   a. There is no sufficient evidence that more than 8% of the potatoes in the shipment have blemishes. Therefore, the truck should be returned.
   b. There is sufficient evidence that more than 8% of the potatoes in the shipment have blemishes. Therefore, the truck should be returned.
   c. There is no sufficient evidence that more than 8% of the potatoes in the shipment have blemishes. Therefore, the truck should not be returned.
   d. There is sufficient evidence that more than 8% of the potatoes in the shipment have blemishes. Therefore, the truck should not be returned.

For nos. 5 to 9, refer to the given problem below.

A public high school wants to increase its reading comprehension rate of 9% for Grade 7 students from the previous year. After planning and implementing new reading programs during the last three years, the school re-evaluated its reading comprehension rate using a random sample of 156 students and found the reading comprehension rate at 10%. Test the claim at 10% level.

5. What is the level of significance of the given problem?
   a. $\alpha = 0.01$ b. $\alpha = 0.05$ c. $\alpha = 0.1$ d. $\alpha = 0.5$

6. What is the null hypothesis?
   a. $H_o : p > 0.09$ c. $H_o : p = 0.09$
   b. $H_o : p < 0.09$ d. $H_o : p \neq 0.09$

7. What is the alternative hypothesis?
   a. $H_a : p > 0.09$ c. $H_a : p < 0.09$
   b. $H_a : p = 0.09$ d. $H_a : p \geq 0.09$

8. If the computed p-value is greater than the given α, which is the correct decision?
    a. Reject the null hypothesis.
    b. Fail to reject the null hypothesis.
    c. Reject both null and alternative hypotheses.
    d. Fail to reject both null and alternative hypotheses.

9. From the correct decision in no. 8, what should be your conclusion?
    a. There is a missing data.
    b. There is an error in the claim.
    c. There is sufficient evidence to claim that the reading comprehension rate is higher during the current year than the previous year.
    d. There is no sufficient evidence to claim that the reading comprehension rate is higher during the current year than the previous year.

10. Which of the following will NOT result to a decision of rejecting the null hypothesis?
    a. The z-score is located at the rejection region.
    b. The p-value is equal to the level of significance.
    c. The test statistic is smaller or larger than the critical value.
    d. The p-value is greater than the level of significance.

11. Why do you need to set the level of significance in solving problems for test of hypothesis?
    a. to determine the test statistic
    b. to identify the margin of error
    c. to easily compute the critical value
    d. to make the probability of making a Type I error small

12. Which is true about using critical value approach and P-value approach?
    a. They are used only for proportions.
    b. They will give you different decisions.
    c. They are used as alternative solutions.
    d. They both have the same results used for drawing conclusions.

For nos. 13 to 15, refer to the given problem below.

The mayor of a town saw an article claiming that the national unemployment rate is 8%. He wondered if this holds true in their town, so a sample of 200 residents was taken. The sample included 22 unemployed residents and 0.05 level of significance was used.

13. Formulate the pair of hypotheses.

a. H_o : p = 0.08
   H_a : p ≠ 0.08

b. H_o : p = 0.08
   H_a : p < 0.08

c. H_o : p = 0.08
   H_o : p = 0.08

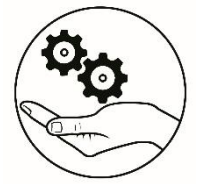
d. H_o : p = 0.08
   H_a : p ≥ 0.08

14. This test is a _____.

a. left-tailed test
b. one-tailed test
c. right-tailed test
d. two-tailed test

15. What is the level of significance (α) in the given problem?

a. 0.01 b. 0.05 c. 0.1 d. 0.5



Additional Activities

Finding the Errors

Read and analyze the given problems below. One of the data/ concepts/values is incorrect. Find the error, then write the correct version. Write your answers on the blanks provided.

1. One thousand five hundred (1,500) randomly selected pine trees were tested for traces of the Bark Beetle infestation. It was found that 153 of them showed such traces. Test the hypothesis that more than 10% of the pine trees have been infested. (Use 5% level of significance.)

   α =0.5

   Ho : p = 0.10

   Ha : p > 0.10

   z_{com} = 1.645

   ERROR: _____

   CORRECTED: _____

2. A sample of 100 students were randomly selected from Pinagpala High School and 18 of them said they are left-handed. Test the hypothesis that less than 20% of the students are left-handed by using $\alpha = 0.05$ as the level of significance.

   H_o: p = 0.20

   H_a: p ≠ 0.20.

   z_{com} = 1.96

   $\alpha = 0.05$.

It is a one-directional or left-tailed test.

ERROR: _____

CORRECTED: _____

3. Newborn babies are more likely to be boys than girls. A random sample found 13,173 boys were born among 25,468 newborn children. The sample proportion of boys was 0.5172. Is this sample evidence that the birth of boys is more common than the birth of girls in the entire population?

   Ho : p = 0.5

   Ha: p > 0.5

   Z_{com} = 5.49

   It is a non-directional or two-tailed test.

   ERROR: _____

   CORRECTED: _____

4. Traditionally, about 70% of students in a Statistics course at ECC are successful. If only 15 students in a class of 28 randomly selected students are successful, is there enough evidence at 5% level of significance to say that students of a particular instructor are successful at a rate of less than 70%?

   H_o : p = 0.70

   H_a: p < 0.70

   P-value = 0.0289

   ERROR: _____

   CORRECTED: _____

   Since P-value < α, we ***fail to reject*** the null hypothesis (H_o).

5. For a class project, a Grade 12 STEM student wants to estimate the percentage of students who are registered voters in his school. From 45% Grade 12 students, he surveys 500 students and finds that 200 are registered voters. Test the claim at α = 0.05 if there is enough evidence proving that there is a change in the percentage of registered voters.

   α = 0.05

   H_o : p ≠ 0.45

   H_a: p ≠ 0.45

   It is a non-directional test.

   ERROR: _____

   CORRECTION: _____

Answer Key

What's In — Give Your Best!

1. a. H_o : (Symbols) $p = 0.30$
   (Statement) The proportion of students who dislike Mathematics is equal to 30%.
   b. H_a : (Symbols) $p \neq 0.30$
   (Statement) The proportion of students who dislike Mathematics is not equal to 30%.
   c. Level of Significance: $\alpha = 0.01$
   d. $n = 1000$ e. $X = 150$ f. $\hat{p} = 0.15$
2. a. H_o : (Symbols) $p = 0.10$
   (Statement) The proportion of students who drink alcohol is equal to 10%.
   b. H_a : Symbols) $p < 0.30$
   (Statement) The proportion of students who drink alcohol is less than 10%.
   c. Level of Significance: $\alpha = 0.05$
   d. $n = 320$ e. $X = 28$ f. $\hat{p} = 0.09$

What's New

4, 3, 1, 5, 2

What I Can Do

Students' answers may vary.

What's More

Make Your Own

Students' answers may vary.

What I Have Learned

1. State the null and alternative hypotheses.
2. Set α or level of significance.
3. Calculate the appropriate test statistic.
4. Determine the critical value or p-value.
5. Make your decision and conclusion.

What I Know

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

Assessment

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

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