

9.4.1: More Practice! Growth Mindset

Scenario

Dr. MO's student researchers at a small community college were interested in changing the growth mindset of students (see the [section on growth mindset](#) for a review), so they asked faculty to have students complete activities that might improve growth mindset. One faculty member, an English professor, had 39 students journal about growth mindset ideas throughout the semester. This activity required students to reflect on barriers that they had overcome, their attitudes about learning, and much more. Another faculty member held discussions over growth mindset ideas throughout the semester in her statistics course; she had 22 students complete the Mindset Quiz. Higher scores on the Mindset Quiz means that the person has a more growth mindset (rather than fixed). The research question was: Which activity worked better to increase scores on the Mindset Quiz: journaling or in-class activities?

Table 9.4.1.1 - Descriptive Statistics of Mindset Quiz Scores by Intervention Type

Sample	Mean	SD	N
Journal	44.77	8.01	39
Mindset Discussions	46.91	6.18	22

Before we get into the details to answer that research question, let's make sure that we understand the scenario. These questions are asking about terms that we learned in [the first chapter](#), if you'd like to review!

? Exercise 9.4.1.1

1. Who is the sample?
2. Who do might be the population?
3. What is the IV (groups being compared)?
4. What is the DV (quantitative variable being measured)? Add exercises text here.

Answer

1. The sample is 61 students from a small community college.
2. There isn't one right answer for this one; I might say "all community college students," but any larger group that the full sample can represent works.
3. The levels of the IV are the two groups being compared, the group of students who journalled about mindset and the group of students who had class discussions. This IV might be called Intervention Type or something similar.
4. The DV is the Mindset Quiz, measured in points.

Okay, let's go!

Step 1: State the Hypotheses

As usual, we will start with the research hypothesis.

? Exercise 9.4.1.2

What is a direction research hypothesis related to the research question? Provide a research hypothesis in words and in symbols.

Answer

- Research Hypothesis: The average Mindset Quiz scores for the sample who journalled will be higher than the average Mindset Quiz scores for the sample who had class discussions about growth mindset.
- Symbols: $\bar{X}_J > \bar{X}_D$

And now, the null hypothesis!

? Exercise 9.4.1.3

What is the null hypothesis for our variables? Provide the null hypothesis in words and in symbols.

Answer

- Null Hypothesis: The average Mindset Quiz scores for the sample who journalled will be similar to the average Mindset Quiz scores for the sample who had class discussions about growth mindset. In order words, there will be no difference between the means.
- Symbols: $\bar{X}_C = \bar{X}_H$

Step 2: Find the Critical Values

The critical values will come from [the t-table](#) that we used for one-sample t-tests (and found in the [Common Critical Value Tables](#) at the back of this book). In this example, we have a one-tailed test at $\alpha = 0.05$. To find the critical t-score, we must first find the Degrees of Freedom for our independent samples.

? Exercise 9.4.1.1

What are the Degrees of Freedom for this independent sample scenario?

Answer

$$df = N_J + N_D - 2 = 39 + 22 - 2 = 59$$

OR

$$df = (N_J - 1) + (N_D - 1) = (39 - 1) + (22 - 1) = 38 + 21 = 59$$

Using that Degrees of Freedom, we now can look at [the t-table](#) that we used for one-sample t-tests (and found in the [Common Critical Value Tables](#) at the back of this book).

? Exercise 9.4.1.1

What is the critical t-score for this scenario?

Answer

The closest Degrees of Freedom in the table is $df = 60$. For that, the critical t-score for $\alpha = 0.05$ is 1.671.

The Degrees of Freedom in the table if you are rounding down is $df = 40$. For that, the critical t-score for $\alpha = 0.05$ is 1.684.

Use the rule that your professor tells you to use!

We are now prepared for the next step of the null hypothesis significance testing process. Although calculating the t-test might seem like it's the most difficult part of the process, students actually have more trouble with the last step (the decision and interpretation).

Step 3: Compute the Test Statistic

The descriptive statistics for both groups were provided in Table 9.4.1.1. Don't forget to take a deep breath before you start!

? Exercise 9.4.1.1

Calculate an independent t-test using the descriptive statistics from Table 9.4.1.1.

After your deep breath, copy down the independent samples t-test formula:

$$t = \frac{(\bar{X}_J - \bar{X}_D)}{\sqrt{\left[\frac{(N_J - 1) * s_J^2 + (N_D - 1) * s_D^2}{N_J + N_D - 2} \right] * \left(\frac{1}{N_J} + \frac{1}{N_D} \right)}}$$

And then fill in all of the numbers from Table 9.4.1.1 into the formula:

$$t = \frac{(44.77 - 46.91)}{\sqrt{\left[\frac{(39 - 1) * (8.01)^2 + (22 - 1) * (6.18)^2}{39 + 22 - 2} \right] * \left(\frac{1}{39} + \frac{1}{22} \right)}}$$

Answer

$$\begin{aligned} t &= \frac{(44.77 - 46.91)}{\sqrt{\left[\frac{(39 - 1) * (8.01)^2 + (22 - 1) * (6.18)^2}{39 + 22 - 2} \right] * \left(\frac{1}{39} + \frac{1}{22} \right)}} \\ t_{Add/Subtract} &= \frac{-2.14}{\sqrt{\left[\frac{(38) * (8.01)^2 + (21) * (6.18)^2}{59} \right] * \left(\frac{1}{39} + \frac{1}{22} \right)}} \\ t_{Square} &= \frac{-2.14}{\sqrt{\left[\frac{(35 * 64.16) + (21 * 38.19)}{59} \right] * \left(\frac{1}{39} + \frac{1}{22} \right)}} \\ t_{Multiply} &= \frac{-2.14}{\sqrt{\left[\frac{(2438.08) + (802.04)}{59} \right] * \left(\frac{1}{39} + \frac{1}{22} \right)}} \\ t_{AddAgain} &= \frac{-2.14}{\sqrt{\left(\frac{3240.12}{59} \right) * \left(\frac{1}{39} + \frac{1}{22} \right)}} \\ t_{Divide} &= \frac{-2.14}{\sqrt{(54.92) * (0.03 + 0.05)}} \\ t_{AddAgainAgain} &= \frac{-2.17}{\sqrt{(54.92) * (0.07)}} \\ t_{MultiplyAgain} &= \frac{-2.14}{\sqrt{3.90}} \\ t_{SquareRoot} &= \frac{-2.14}{1.98} \\ t_{TheEnd!} &= -1.08 \end{aligned}$$

Ack, this is a negative calculated t-score! But that's okay, it's not a computational error. It just means that the mean that I started with was smaller than the second mean. What to note is that you use the absolute value when comparing to the critical t-score (so, act like it's a positive calculated t-score when determining if it's bigger or smaller than the critical t-score).

Step 4: Make the Decision

We have good reason to believe that there is actually no difference in Mindset Quiz scores between the two types of mindset interventions. Our calculated test statistic has a value of $t = -1.08$, and in Step 2 we found that the critical value is $t^* = 1.671$ (if you used the closest Degrees of Freedom). $1.671 > |-1.08|$, so we retain (fail to reject) the null hypothesis because:

$$\begin{aligned} |Critical| < |Calculated| &= \text{Reject null} = \text{means are different} = p < .05 \\ |Critical| > |Calculated| &= \text{Retain null} = \text{means are similar} = p > .05 \end{aligned}$$

Let's look back at the research hypothesis:

- Research Hypothesis: The average Mindset Quiz scores for the sample who journalled will be higher than the average Mindset Quiz scores for the sample who had class discussions about growth mindset.
- Symbols: $\bar{X}_J > \bar{X}_D$

Writing the Conclusion

Based on our sample data from student who learned about growth mindset topics, the average Mindset Quiz score for the group who journalled on growth mindset topics ($\bar{X}_J = 44.77$) was similar than the average Mindset Quiz score for the group who had discussions about growth mindset ($\bar{X}_D = 46.91$), $t(59) = -1.08, p > .05$. This does not support our research hypothesis. In the end, the two types of intervention work equally well.

There are some things to note about the statistical sentence. First, the Degrees of Freedom in the parentheses are what was calculated ($df = 59$), not the Degrees of Freedom that we had to use from the table. Second, the negative calculated t-score is included in the statistical sentence, even though we used the absolute value when comparing to the critical value from the table.

Also, if you read the scenario closely, you might have noticed that the IV (type of mindset intervention) was confounded with the type of class that the students were in. This is the type of problem that you run into when conducting field experiments (experiments in real-life settings)! Because of this, an alternate conclusion is that there is no different in Mindset Quiz scores between the two class types (English or Statistics) $t(59) = -1.08, p > .05$. If there had been a difference, we wouldn't know if improved mindset was because of the intervention of journaling or because students in English classes have better mindsets. #ScienceIsHard

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Dr. MO (Taft College)

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