Title of Resource: Hand Calculation: t-test for Dependent Means (Thinking Logically Over Time)

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Brief Description: This activity can be used as practice after students have learned how to hand calculate a t-test for dependent means.

Keywords: t-test for Dependent Means; Hand Calculation

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**Instructors:**
Instructors should assign this problem to students as in-class practice or homework after students have learned how to calculate a t-test for dependent means and test for significance. The activity leads students through determining the type of statistical analysis to use, the hypotheses, calculating the t-ratio and effect size (if appropriate), making a decision about the null hypothesis and summarizing the results. An answer key is included.
An experimental psychologist believed the training students received in his graduate program changed their ability to think logically. He gave a logical thinking test to eight students who just entered the program, then four years later, he gave the same students the logical thinking test again. It is predicted that there will be a difference in the number of errors between Year 1 and Year 4. The number of errors made by each student is shown below.

<table>
<thead>
<tr>
<th>Student</th>
<th>Year 1</th>
<th>Year 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>10</td>
<td>5</td>
</tr>
<tr>
<td>2</td>
<td>15</td>
<td>2</td>
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<tr>
<td>3</td>
<td>6</td>
<td>7</td>
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<tr>
<td>4</td>
<td>11</td>
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<tr>
<td>5</td>
<td>7</td>
<td>0</td>
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<tr>
<td>6</td>
<td>13</td>
<td>10</td>
</tr>
<tr>
<td>7</td>
<td>8</td>
<td>2</td>
</tr>
<tr>
<td>8</td>
<td>12</td>
<td>4</td>
</tr>
</tbody>
</table>

1. Which type of test will you use? Support your answer.

2. State \( H_0 \) and \( H_1 \).

3. Is this a one-tailed or two tailed test? Why?

4. What are the df associated with this test?

5. What is/are the critical value(s) one should use to test the researcher’s hypothesis at the .05 level?

6. Calculate the \( t \)-ratio. Be sure to show all of your work.

7. Make a decision about the null hypothesis and support your decision.

8. Calculate the effect size, if applicable, and what effect size tells us.

9. Give a summary statement about the results. Think about the decision on the null, the group means and effect size (when applicable).
An experimental psychologist believed the training students received in his graduate program changed their ability to think logically. He gave a logical thinking test to eight students who just entered the program, then four years later, he gave the same students the logical thinking test again. It is predicted that there will be a difference in the number of errors between Year 1 and Year 4. The number of errors made by each student is shown below.

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</tr>
</tbody>
</table>

1. Which type of test will you use? Support your answer.

The appropriate test is a \( t \)-test for dependent means. The study involves pre and post testing, therefore groups are related.

2. State \( H_0 \) and \( H_1 \).

\[ H_0: \text{There is no difference in errors (logic scores) between Year 1 and Year 4.} \]
\[ H_1: \text{There is a difference in errors (logic scores) between Year 1 and Year 4.} \]

3. Is this a one-tailed or two-tailed test? Why?

The alternative hypothesis is non-directional therefore it should be a two-tail test.

4. What are the df associated with this test?

\[ df = N - 1 \rightarrow 8 - 1 = 7 \]

5. What is/are the critical value(s) one should use to test the researcher’s hypothesis at the .05 level?

2.365

6. Calculate the \( t \)-ratio. Be sure to show all of your work.

<table>
<thead>
<tr>
<th>( X_1 )</th>
<th>( X_2 )</th>
<th>D</th>
<th>( D - M_D )</th>
<th>( (D - M_D)^2 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>5</td>
<td>5</td>
<td>5-6 = -1</td>
<td>1</td>
</tr>
<tr>
<td>15</td>
<td>2</td>
<td>13</td>
<td>13-6= 7</td>
<td>49</td>
</tr>
<tr>
<td>6</td>
<td>7</td>
<td>-1</td>
<td>-1-6=- 7</td>
<td>49</td>
</tr>
<tr>
<td>11</td>
<td>4</td>
<td>7</td>
<td>7-6 = 1</td>
<td>1</td>
</tr>
<tr>
<td>7</td>
<td>0</td>
<td>7</td>
<td>7-6 = 1</td>
<td>1</td>
</tr>
<tr>
<td>13</td>
<td>10</td>
<td>3</td>
<td>3-6 = -3</td>
<td>9</td>
</tr>
<tr>
<td>8</td>
<td>2</td>
<td>6</td>
<td>6-6 = 0</td>
<td>0</td>
</tr>
<tr>
<td>12</td>
<td>4</td>
<td>8</td>
<td>8-6 = 2</td>
<td>4</td>
</tr>
<tr>
<td>( \Sigma X_1 = 82 )</td>
<td>( \Sigma X_2 = 82 )</td>
<td>( \Sigma D = 48 )</td>
<td>( \Sigma(D - M_D)^2 = 114 )</td>
<td></td>
</tr>
<tr>
<td>( N_1 = 8 )</td>
<td>( N_2 = 8 )</td>
<td>( M_D = 6.00 )</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
7. Make a decision about the null hypothesis and support your decision.

The null hypothesis should be rejected as the \( t \)-ratio calculated is greater than critical value \( t \). The group means are significantly different from Year 1 to Year 4.

8. Calculate the effect size, if applicable, and what effect size tells us.

\[
S^2_D = \frac{\sum (D - M_D)^2}{N - 1} \quad S^2_D = \frac{114}{8 - 1} \quad S^2_D = \frac{114}{7} \quad S^2_D = 16.29
\]

\[
t = \frac{M_D}{\sqrt{\frac{1}{N}S^2_D}} \quad t = \frac{6}{\sqrt{\frac{1}{8}16.29}} \quad t = \frac{6}{\sqrt{2.036}} \quad t = \frac{6}{1.43} \quad t = 4.20
\]

7. Make a decision about the null hypothesis and support your decision.

The null hypothesis should be rejected as the \( t \)-ratio calculated is greater than critical value \( t \). The group means are significantly different from Year 1 to Year 4.

8. Calculate the effect size, if applicable, and what effect size tells us.

\[
r_{\text{effect size}} = \sqrt{\frac{t^2}{t^2 + df}} \quad r_{\text{effect size}} = \sqrt{\frac{4.20^2}{4.20^2 + 7}} \quad r_{\text{effect size}} = \sqrt{\frac{17.64}{24.64}} \quad r_{\text{effect size}} = 0.7159
\]

\[r_{\text{effect size}} = 0.85\]

This is a strong effect size meaning that finding (difference) is an important one.

9. Give a summary statement about the results. Think about the decision on the null, the group means and effect size (when applicable).

There is a significant and important difference between the number of errors (logic scores) in Year 1 as compared to Year 4. Students made fewer errors in Year 4 (M = 4.25) than Year 1 (M = 10.25) indicating that their ability to think logically improved through their graduate program training.