Determining differences in absorbance readings for two brands of food dye: An example of independent samples

This worksheet accompanies the article:

Martinez-Dawson, R. (2003) "Incorporating laboratory experiments in an introductory statistics course," *Journal of Statistics Education* [Online], 11(1). http://www.amstat.org/publications/jse/v11n1/martinez-dawson.html

Purpose:

The purpose of this experiment is to illustrate the concepts of sampling involving two independent samples, statistical analysis of the samples, and drawing a conclusion based on the analysis.

A consumer group was interested in determining if there is a difference in color intensity of two brands of red food dye. One brand is considerably less expensive than the other brand. Color intensity will be measured in terms of absorbance readings.

You will perform a spectrophotometric experiment and conduct a hypothesis test to determine if the solutions containing one drop of dye from the two brands of food color have different mean absorbances at 570 nanometers (nm). Based on Beer's Law, the absorbance of a solution is correlated with the concentration of a solution. A higher absorbance indicates a more concentrated solution and more intense color.

Materials:

You will need the following materials: spectrophotometer, cuvette, glass, dropper, water, red food color, and kimwipes.

Procedures:

The spectrophotometer will be plugged in and should be allowed to warm up for 15 minutes. Set the wavelength at 570 nm. For all readings, use the same cuvette.

Using the knob on the left, zero the spectrophotometer. Fill the glass with 20 ml. of water. Using a dropper, fill the cuvette two-thirds full with water. Wipe the cuvette with a kimwipe so that there are no finger prints on the cuvette. Open the black lid of the cuvette holder and carefully place the cuvette in the chamber so that the line on the cuvette matches up with the line on the chamber. SLOWLY lower the black lid. With the knob on the right, set the spectrophotometer at 100%T (upper scale) or 0.0 A (lower scale).

Pour the water from the cuvette back into the glass with the remaining water. Fill the dropper with dye from one brand of red food color and CAREFULLY put ONE DROP into the 20 ml of water. Pour the rest of the food color back into the container. Stir the food color solution with a provided stirrer. Fill the cuvette two-thirds full with this solution. Wipe the cuvette with a kimwipe and read the absorbance (lower scale). Record the absorbance in the table below. Pour the solution in the cuvette and in the glass down the provided sink. Rinse the cuvette with water between each reading.

Fill another beaker with 20 mls of water and add ONE DROP of red food color from the other brand of red dye. Stir. Fill the cuvette two-thirds full with this solution and record the absorbance in the table below. Throw the solution down the sink and clean and dry all items used.

The class should have three absorbance readings for each type of solution (one drop of Brand 1 or one drop of Brand 2).

Absorbance at 570 nm for solutions with the two brands of red food color

Brand=	**Brand=**

Statistical analysis:

Conduct a hypothesis test to determine if there is a difference in the mean absorbances for the two brands of food dye. (α =.05)

1. State the null and alternative hypotheses. Define the parameter(s). (4 pts)

2. Calculate the test statistic. Show all your work. (10 pts)

3. Determine the approximate p-value. Be as precise as possible. (6 pts)

4. What is the decision? Explain. (2 pts)

5. What is the conclusion? (2 pts)

Conduct the hypothesis test using SAS. Type the following code (in bold) to perform the hypothesis test using the p-value method. A description of any new code will appear to the right of the SAS code.

data red;
input soln $ abs;
cards;

In the first column, type the brand name of the dye used, skip a space, and type the absorbance for that solution. Move to the next line. Do this for all absorbances.

proc sort;
by soln;
proc ttest; Produces the t-test
class soln; The class variable, soln, has 2 values (brand names)
var abs; The variable, abs, is the response.
title Type your name here**;**
run;
quit;

Questions based on the SAS output

6. Based on the printout, what are the average absorbances for the solutions made using the two brands of red food dye? (2 pts)

The formula for the test statistic is:

$$t_{obs} = \frac{(\bar{x}_1 - \bar{x}_2) - \delta_0}{S_p\sqrt{\frac{1}{n_1} + \frac{1}{n_2}}} \qquad where\ S_p = \sqrt{\frac{(n_1 - 1)s_1^2 + (n_2 - 1)s_2^2}{n_1 + n_2 - 2}}$$

7. Put the correct values from the printout into the test statistic formula. (4 pts) Note: SAS will order the statistics in parentheses in the numerator in alphabetical order.

t_{obs} =

8. Assuming equal variances, identify the test statistic **on the printout** by labeling it t_{obs}. Write the degrees of freedom below. (2 pts)

9. Identify the p-value **on the printout**. (2 pts)

10. Draw the t-distribution and indicate the area that corresponds to the p-value. (4 pts)

11. What is the decision? Explain. (4 pts)

12. Based on the hypothesis test, what is the conclusion? (2 pts)

13. Identify two sources that could contribute to variation in absorbances. (4 pts)

14. Write the confidence interval (LCL, UCL) for the difference in the mean absorbance for the two brands of food dye. (2 pts)