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LESSON 18 - ANOVA

In this lesson we will learn how to make use of Minitab to do ANOVA problems. As an example we will do Problem 15 on page 598. We will let Minitab check that the conditions for ANOVA are satisfied and do the necessary computations, then we will use those results to write up our conclusions using the 5-step classical hypothesis testing procedure on a separate piece of paper. Enter the data and label the columns. Clear the Session Window below the time/date stamp and type your name, Lesson 18, and Example. Since the writeup will be on a separate paper, we need not type in the definition of the variables at this point. Display the data.

Recall that ANOVA requires that each data set be reasonably normal and that the largest sample standard deviation be less than twice the smallest sample standard deviation. We will use the Graphical Summary form of Basic Statistics to check these conditions. When you get into the Graphical Summary dialog box highlight all four variables by dragging the mouse down the list and select all four into the 'Variables:' box. This way you can do all four at once. The results of the Anderson-Darling Normality Test and the standard deviations are shown below.

Grade 9 ANOVA OK		Grade 10 ANOVA OK		Grade 11 ANOVA OK		Grade 12 ANOVA OK	
Anderson-Darling Normality Test		Anderson-Darling Normality Test		Anderson-Darling Normality Test		Anderson-Darling Normality Test	
A-Squared	0.28	A-Squared	0.31	A-Squared	0.28	A-Squared	0.19
P-Value	0.533	P-Value	0.481	P-Value	0.541	P-Value	0.841
Mean	84.375	Mean	79.250	Mean	76.625	Mean	70.750
StDev	26.960	StDev	25.711	StDev	21.633	StDev	19.580

We can see that the standard deviation is not a problem; the largest is 26.960, which is certainly less than twice the smallest, which is 19.580. Normality is pretty "iffy". Since we are using a level of significance of 0.01, however, they all make it, so we can proceed with ANOVA.

To do the analysis of variance click on Stat > ANOVA > One-way (Unstacked), select all the variables into the "Responses (in separate columns):" box, and click "OK". The session window is printed on the next page. Notice that Minitab gives us an ANOVA table for this data, but it looks a bit different from the notation in our text. First of all, the sum of squares column and the degrees of freedom column are switched. Also, the row our text calls "Between samples" is named "Factor" by Minitab, and the text's "Within samples" row is called "Error" by Minitab. In our text, an ANOVA table does not include total numbers. A total number is simply the sum of two numbers above in the column. Notice also that Minitab gives us both the value of F and the P-Value.

This is all you will do on the computer. Now, by hand and on a separate sheet of paper, go through the 5-step classical hypothesis testing procedure. Under "For our sample" in step 3, write in the ANOVA table using the results from Minitab, but use the format from our text. When you do the assignment for this lesson you will turn in the printed Session Window and the paper with the hypothesis testing procedure written out. A sample of the 5-step classical method

for this example is on the page following the Session Window page. (NOTE: This sample is typed, but yours may be done by hand.)

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Jeonghun Kim
Lesson 18
Example

Data Display

```
              Grade  Grade  Grade
Row  Grade 9     10     11     12
  1       82     77     86     65
  2       91     87     81     77
  3       53     58     46     42
  4      133    125    115    102
  5       64     51     56     49
  6      112    106     87     84
  7       63     58     62     65
  8       77     72     80     82
```

One-way ANOVA: Grade 9, Grade 10, Grade 11, Grade 12

```
Source  DF     SS   MS     F      P
Factor   3    771  257  0.46  0.713
Error   28  15675  560
Total   31  16446

S = 23.66   R-Sq = 4.69%   R-Sq(adj) = 0.00%


                          Individual 95% CIs For Mean Based on
                          Pooled StDev
Level     N   Mean  StDev  -----+---------+---------+---------+----
Grade 9   8  84.37  26.96            (-------------*-------------)
Grade 10  8  79.25  25.71         (-------------*-------------)
Grade 11  8  76.63  21.63      (-------------*-------------)
Grade 12  8  70.75  19.58   (-------------*-------------)
                          -----+---------+---------+---------+----
                              60        72        84        96

Pooled StDev = 23.66
```

SAMPLE WRITE-UP

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August 12, 2009
Lesson 18
Example

Variables: X1 = A number of female students who played on a sports team in grade 9
X2 = A number of female students who played on a sports team in grade 10
X3 = A number of female students who played on a sports team in grade 11
X4 = A number of female students who played on a sports team in grade 12

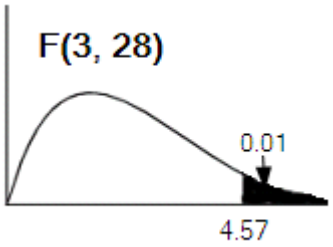
1. H_0: $\mu_1 = \mu_2 = \mu_3 = \mu_4$ (claim)
   H_a: At least one mean is different from the others.

2. $\alpha = 0.01$

3. Assume H_0 is true. $F = \dfrac{MS_B}{MS_W} \sim F(k-1, N-k)$

   For our sample: $k = 4$, $N = 32$ and $F = \dfrac{257}{560} = 0.46 \sim F(3, 28)$.

Variation	Sum of squares	Degrees of freedom	Mean squares	F
Between	771	3	257	0.46
Within	15675	28	560	

4. 

Reject H_0 if $F > 4.57$ from Table 7.

5. Decision: Since $F = 0.46 < 4.57$, fail to reject H_0.
   Conclusion: There is insufficient evidence at the 1% level of significance to reject the claim that the mean numbers of female students are equal for all grades.

MINITAB ASSIGNMENT 18

See instructions on page 8.

Do each of the following problems as the example was done in this lesson. Turn in the Session Window, all the graphs from the Graphical Summary, and the 5-step classical method write-up. **Note**: Use the P-value appeared in the session window to make a decision for your write-up instead of using the critical value F_0. (in fact, we cannot find F_0 from our F-distribution table)

1. Problem 10 on page 597.

2. Problem 14 on page 598.

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