ACTION RESEARCH
SESSION 5.3
QUANTITATIVE ANALYSIS
PART II: INFERENTIAL STATISTICS

Objectives

At the end of the session, teachers should be able to:

1 state the purpose of inferential statistics in data analysis;
2 observe the steps in testing hypotheses;
3 differentiate the uses of independent t-test and paired t-test; and
4 use statistical software in computing inferential statistics of given data to answer research questions about means.

Key Understandings

1 Inferential statistics is used to make inferences about a population based on data collected from a sample representative.
2 Independent t-test is an inferential statistic applied when comparing means obtained from two groups (e.g., experimental and control, boys and girls).
3 Paired t-test is an inferential statistic used when comparing two means obtained from the same group (e.g., pretest and posttest).

Materials

- Calculator
- LCD projector
- Laptops with pre-installed MS Excel Add-ins or any statistical software
- Scratch papers
- Pencils
- Marking pens
- Masking tape
- At least two (2) flash drives to aggregate data encoded separately by groups
- Blank forms of coding guide sheet (see sample at the end of this material)
- Copies of data sheets on boys' and girls' manipulative test scores; one per group (as shown later in this guide)
- Copy of data set on manila paper to be posted on the board with spaces for descriptive statistics (see sample poster at the end of this material)
- copies of data sheet for task under *Application* with tables for outputs
- copies of blank hypothesis testing sheet

TIME ALLOTMENT
120 minutes/2 hours

References

Fraenkel, Jack R. and Norman E. Wallen. (1990) 2008 *How to Design and Evaluate Research in Education.* Boston: McGraw Hill.

Levin, Jack A, James Allan Fox, and David R. Forde. (2003) 2013 *Elementary Statistics in Social Research.* New York: Pearson.

Shafer, Douglas S. and Zhiyi Zhang. 2013 Introductory Statistics. Flat World Knowledge. Accessed May 12, 2018 https://www.saylor.org/site/textbooks/Introductory%20Statistics.pdf.

Introduction

Begin the learning session by saying: "Good _____, everyone. I am glad to see all of you today for our LAC session. I am _____, your facilitator. Today, we will continue our discussion on data analysis in Action Research. We will be talking about making statements or inferences about populations based on observations taken from a sample. We will be observing the steps in testing hypotheses, which requires the use of inferential statistics. We will be giving emphasis to the two *t*-tests, one of which is used in comparing means obtained from one group tested or measured twice while the other one is for comparing means from two groups.

At the end of the session, you are expected to be able to state the purpose of inferential statistics in data analysis; observe the steps in testing hypotheses; differentiate the research questions addressed by independent *t*-test and paired *t*-test; and use statistical software in computing inferential statistics on given data to answer research questions."

Activity (15 minutes)

Lead the participants in computing descriptive statistics on data that will be used later to demonstrate the use of the MS Excel Add-ins particularly in computing inferential statistics. Observe the following instructions.

1   Organize the participants into four small groups. Make sure that each group has a laptop with pre-installed MS Excel Add-Ins. Pay special attention to those who may be using the software for the first time and assist them.

2   Distribute to the groups two sets of data on manipulative test scores of boys and girls, so that two groups will be working on boys' data while the other two groups on girls' data Also, give them copies of coding guide sheets.

3   Ask the participants to prepare a coding guide for the data and then to encode them following it. Have the participants show you the coding guide that they have prepared before letting them enter the data Make sure that everybody is using a similar data format as presented below. This will facilitate the aggregation of data for the t-tests later. Allot 10 minutes for this task.

4 After making sure that the coding guides prepared by the participants are correct and the data are properly encoded, ask them to compute for the descriptive statistics (as discussed in the previous LAC session). Advise them to use basic MS Excel operations in computing the required statistics.

TABLE --. Coding Guide for Data on Manipulative Test Scores of Boys and Girls

Column Number	Variable*	Variable Label*	Value	Value Label	Level of Measurement
1	ID	ID number	as is		nominal
2	gender*	gender	1	boy	nominal
			2	girl	
3	score*	manipulative test score	as is		ratio

*NOTE: The variable names will differ, but the variable labels must be accurate.

TABLE --. Data on Manipulative Test Scores of Boys and Girls

GROUPS 1 & 3 DATA		GROUPS 2 & 4 DATA	
ID	Boys' Scores	ID	Girls' Scores
B1	32	G1	21
B2	28	G2	23
B3	24	G3	18
B4	23	G4	19
B5	27	G5	22
B6	34	G6	21
B7	32	G7	25
B8	20	G8	27
B9	12	G9	16
B10	18	G10	13

TABLE --. Descriptive Statistics on Manipulative Test Scores of Boys and Girls

STATISTICS	GENDER GROUPS	
	Boys	Girls
Mode	3200	2100
Median	2550	2100
Mean	2500	20.50
Maximum	3400	2700
Minimum	1200	1300
Range	2200	1400
Variance	4889	1739
Standard Deviation	699	417

Once the groups have finished their tasks, ask one participant each from those working on boys' data and on girls' data to write the results on posters.

Analysis (10 minutes)

Lead the participants in processing the results of the pre-discussion activity by asking them the following guide questions.

1 What can you say about the two groups, boys and girls, based on the descriptive statistics computed? Which group performed better? Which group is more homogeneous? (*Boys performed better than girls; their mean is higher. The girls are more homogeneous; the standard deviation is smaller.*)

2 Based on the three measures of location, what can be said about the distribution of manipulative test scores of boys and of girls? (*The distributions are both skewed to the right or positively skewed because the means are higher than the modes.*)

3 Given these descriptive statistics, can we categorically say that boys are *definitely better* than girls when it comes to manipulative tests? (*No, we need to compute inferential statistics, such as the* t-*test, to be able to make generalizations.*)

Abstraction (60 minutes)

Begin the discussion by saying: "As we have just realized, we *cannot* make generalizations about the population based on our sample of students simply by using descriptive statistics. If we want to make interpretations about a population using results obtained from a sample, we will have to use a different type of statistic called *inferential statistics*.

For our session today, we will be discussing only two inferential statistics, both of which are applied to two means. One is commonly used in comparing means obtained from a single group, as in the case of pretest and posttest means. The other is used in comparing means obtained from two groups. We will look into how these inferential statistics provide evidence for us to make conclusions about a population based on data obtained from a sample."

NOTE TO THE FACILITATOR:
Instruct the participants to close their laptops and set aside their work from the *Activity* as you discuss inferential statistics. Inform them that they will be returning to the data after your discussion.

HYPOTHESIS TESTING

Making generalizations about the effectiveness of an intervention or treatment on the basis of experiments conducted on a population sample is the process of *hypothesis testing*. This is a statistical method used in making decisions about parameters using statistics computed from sample data It basically involves examining the likelihood of the null hypothesis being true. The following are the seven (7) basic steps of hypothesis testing.

1 **Formulate the research question**. All research activities begin with a research question. It is what drives the inquiry and gives direction to the researcher on the subsequent procedures to be undertaken.

2 **State the null hypothesis**. In comparing two means, the null hypothesis asserts that there is no difference between the population means (μ) of groups 1 and 2

$$\mu_1 - \mu_2 = 0$$

Another way of stating the null hypothesis is to say that the two means are equal as shown below. Its alternative, then, states that the two groups are *not* equal.

$$H_0 : \mu_A = \mu_B$$

$$H_1 : \mu_A \neq \mu_B$$

Remember that it is the null hypothesis that is tested; its likelihood of being true is examined in hypothesis testing. The null hypothesis is set up to be *rejected* first for us to *accept* the hypothesis of *our* interest, which is the research hypothesis. We want to be able to *accept* the research hypothesis which states that there *is* a difference between means.

3 **Specify the level of significance.** The *likelihood* of the null hypothesis being *true* is set at a minimum. In Social Science, it is five (5) percent or five in a hundred (0.05). In medical science though, the value may be more extreme; sometimes one (1) in a thousand or 0.001 This value is called the *level of significance* or *significance level*, also known as *alpha level* (α). Technically, the alpha level is the percentage of error we are willing to risk in rejecting the null hypothesis. Hence, an alpha level of α = 0.05 means that we are willing to be in error five (5) out of a hundred or five percent.

A concept related to level of significance is *level of confidence*. It is simply 1-α. Therefore, if our alpha level or level of significance is α = 0.05, our level of confidence is 0.95 This is the same as saying we are *95% confident* that whatever conclusion we derive from rejecting the null hypothesis is *correct*.

4 **Compute the inferential statistic** Since populations are often either too large or too indefinite to study, we just take a sample (preferably random). We collect data from them and compute the inferential statistic, such as the *t*-statistic used in comparing two means.

5 **Compare the obtained or computed statistic with the critical value**. For each sample size n and alpha level, a *minimum* or *critical value* has already been determined These values may be found in a table similar to the one below.

Degrees of freedom (n-1)	α = 0.20	0.10	0.05	0.02	0.01	0.002
			Two Tailed Significance			
1	3.078	6.314	12.706	31.821	63.657	318.300
2	1.886	2.920	4.303	6.965	9.925	22.327
3	1.638	2.353	3.182	4.541	5.841	10.214
4	1.533	2.132	2.776	3.747	4.604	7.173
5	1.476	2.015	2.571	3.305	4.032	5.893
6	1.440	1.943	2.447	3.143	3.707	5.208
7	1.415	1.895	2.365	2.998	3.499	4.785
8	1.397	1.860	2.306	2.896	3.355	4.501
9	1.383	1.833	2.262	2.821	3.250	4.297
10	1.372	1.812	2.228	2.764	3.169	4.144
11	1.363	1.796	2.201	2.718	3.106	4.025
12	1.356	1.782	2.179	2.681	3.055	3.930
13	1.350	1.771	2.160	2.650	3.012	3.852
14	1.345	1.761	2.145	2.624	2.977	3.787
15	1.341	1.753	2.131	2.602	2.947	3.733

FIGURE --. Two Tailed Significance

Another comparison that can be made is with the significance or alpha level and the *probability* associated with the obtained or computed *t*-value. Many statistical software now give not only the *t*-value but also the probability or *p*-value. The rule is that the *p*-value must be *lower* than the alpha level.

6 **Decide on the null hypothesis.** In order to *reject* the null hypothesis, the obtained or computed inferential statistic (such as the *t*-statistic) has to *exceed* the critical value set in the table based on sample size n and the level of significance. For example, if the sample size is n = 16 and the level of significance (or alpha level) is 0.05, the critical *t*-value is 2131 The *t*-value we obtain using the data from our sample *must* be *higher* than this value for us to reject the null hypothesis and, consequently, accept our research hypothesis. If the computed *t*-value is *less* than the critical value, we cannot reject the null; therefore, we must *retain* it. This, however, does *not* mean that we are rejecting our research hypothesis. All things still stand We need to redesign the study, increase sample size, or improve our sampling and data collection methods to find support for our research hypothesis.

7 **Draw the conclusion.** Based on the decision on the null hypothesis, we either conclude that there *is* a difference between the two means, possibly meaning that the intervention or treatment has *worked* in our favor (if we *reject* the null hypothesis), or declare that there is *no* difference between them (if we *fail to reject* the null hypothesis). The conclusion then is the answer to the research question.

Note that simply saying that "there is a difference" between two means does *not* necessarily mean that the difference is in the direction we hoped; say, the experimental group did *better* than the control group or that the posttest is *higher* than the pretest. It could be the other way around; the control group did *better* than the experimental group or the pretest is *higher* than the posttest.

Inferential statistics, unlike descriptive statistics, are used to make statements about a population based on observations taken from a sample. They are used to draw conclusions about the unknown characteristics of a population called *parameters* based on the known characteristics of a sample called *statistics*. Parameters are symbolized by Greek letters such as the **μ** (pronounced as "myu") and **μ** (pronounced as "sigma"), while statistics are symbolized by Latin letters such as M for mean and S or SD for standard deviation.

1 **Independent t-test**

Return to the manipulative test scores of boys and girls. Since the members of the two groups are *different* and are *not* related to one another, the inferential statistic for two *independent* means is the *independent t-test*, also known as *independent samples t-test*. The following is the formula for independent *t*-test, where the numerator is the difference between the two group means and the denominator requires the variances of the two groups, each divided by its own sample size.

$$ t = \frac{\overline{X}_1 - \overline{X}_2}{\sqrt{\dfrac{s_1^2}{N_1} + \dfrac{s_2^2}{N_2}}} $$

Independent *t*-test is used when comparing the means of two groups on the same variable. If the results of the independent *t*-test show that the mean of one group is significantly higher than that of the other group, then it can be concluded that there is a *statistically significant* difference between the two and this can be *generalized* to the *populations* of boys and girls.

2 **Paired or Correlated t-test**

Having found out that girls do poorly on manipulative tests, suppose a teacher decides to implement an intervention or treatment in the form of exercises designed to develop hand-eye coordination and other manipulative skills. He or she might randomly select a group of girls, give the manipulative test first as pretest, and then implement the intervention for one grading period (see the following table). At the end of the grading period, he or she may administer the same manipulative test, this time as *posttest*.

FIRST GRADING PERIOD									
Wk 1	Wk 2	Wk 3	Wk 4	Wk 5	Wk 6	Wk 7	Wk 8	Wk 9	Wk 10
Pretest			Manipulative Exercises						Posttest

Results of the pretest and posttest are subjected to inferential statistics. The appropriate inferential statistic is the *paired* t-*test* or *correlated* t-*test*. The following is the formula for paired *t*-test, where *d* is the difference between the paired values such as pretest and posttest.

$$t = \frac{\Sigma d}{\sqrt{\dfrac{n\left(\Sigma d^2\right) - \left(\Sigma d\right)^2}{n-1}}}$$

If the *t*-value shows that the difference between the means at posttest is significantly higher than the means obtained at pretest, the researcher may conclude that the exercises are effective in improving the manipulative skills of girls.

Paired *t*-test is used to compare two means obtained from the same group. Another example is the situation when we want to compare siblings, say a brother and a sister in terms of their attitude towards school. Since the two are related, we have to use the paired *t*-test.

Take note that there are other inferential statistics, such as the *Analysis of Variance* (ANOVA) or F-*test* for comparing three or more means and *Chi Square* when data are in the form of frequencies. Read about them through statistical reference materials.

COMPUTING T-TEST USING MS EXCEL

Let us return to the data on manipulative test scores of boys and girls. We already know that numerically, the mean obtained by boys is higher than that computed for girls.

NOTE TO THE FACILITATOR:
Refer to the descriptive statistics on the poster generated from the pre-discussion activity. See the following table.

TABLE --. Descriptive Statistics on Manipulative Test Scores of Boys and Girls

STATISTICS	GENDER GROUPS	
	Boys (n = 10)	Girls (n = 10)
Mode	3200	2100
Median	2550	2100
Mean	2500	20.50
Maximum	3400	2700
Minimum	1200	1300
Range	2200	1400
Variance	4889	1739
Standard Deviation	699	417

However, just by looking at the numerical values, we *cannot* categorically generalize and say that boys are *better* at manipulatives than girls. To do this, we need to

engage in hypothesis testing. Let us go through this process using the data on manipulative test scores of boys and girls and following the seven (7) steps introduced earlier.

1   **Formulate the research question.** We want to compare the boys and the girls in terms of scores on the manipulative test. What might be our research question? We can ask:

> *Is there a difference between boys and girls in terms of scores on the manipulative test?*

We can also reword the question to:

> *Do boys and girls differ with regard to scores on the manipulative test?*

2   **State the null hypothesis and its alternative.** The hypotheses for the first sample research question (*Is there a difference between boys and girls in terms of scores on the manipulative test?*) are as follows:

> Null Hypothesis (H_0): *There is no difference between boys and girls in terms of scores on the manipulative test.*
>
> Research Hypothesis (H_1 or H_A): *There is a difference between boys and girls in terms of scores on the manipulative test.*

For the second sample research question (*Do boys and girls differ with regard to scores on the manipulative test?*), the hypotheses are as follows:

> Null Hypothesis (H_0): *Boys and girls do not differ with regard to scores on the manipulative test.*
>
> Research Hypothesis (H_1 or H_A): *Boys and girls do differ with regard to scores on the manipulative test.*

3   **Specify the level of significance.** Let us set the level of significance at the conventional value which is $\alpha = 0.05$ Given that the sample size for both groups is n = 10, the degrees of freedom (df) is (n-1) + (n-1), which is 9 + 9 = 18 We "lose one degree of freedom" for each sample. Given that df = 18 and the level of significance is $\alpha = 0.05$, the critical t value is $t_{crit} = 210$ (see table provided at the end of this material).

4   **Compute the inferential statistic** We do not have to compute the statistic by hand as there are computer programs that can facilitate this.

Say: "You will recall that each group has earlier encoded part of the data Now, I would like groups 1 and 2 to merge their data so that they can have one data set containing 20 cases (n = 20), ten boys and ten girls. Let us do that now."

Allow the participants to sit together to assemble their data by copying and pasting. The resulting MS Excel worksheet should look like the following. Show the spreadsheet of the data to the participants.

From here on, demonstrate the following steps through your laptop. Project the MS Excel window on a screen for everyone to see. Walk through the steps slowly and give the participants enough time to catch up with your demonstration.

a   On the toolbar, click on **Data** then choose **Data Analysis** button (Figure --). You will see a window listing the various statistical tests that MS Excel can perform. Scroll down to find the *t*-test option and click **OK**.
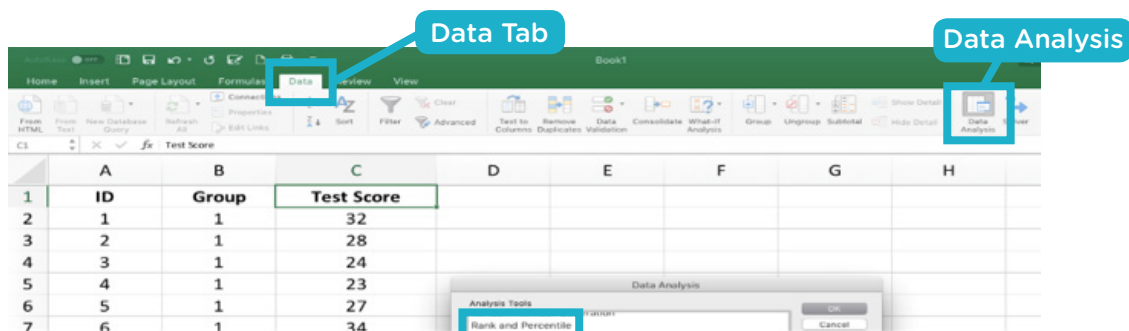

FIGURE --. Data Analysis Option on MS Excel

b   Define the data that will be analyzed In the menu box, click the **Variable 1 Range** box and then use the cursor to select the column containing the data for "Test Score" for the boys labelled as "1" under the column for "Group" (Figure 2). As you select the cells in your spreadsheet, the range should also appear in the menu box window. Repeat the process for **Variable 2 Range** but this time, select the cells under "Test Score" that correspond to "2" under the column for "Group".

c   For the "**Hypothesized Mean Difference**," you can put in zero (0). You can change the output options. For the value of alpha, keep it at the default 0.05, the conventional value for research in Education and Social Sciences.
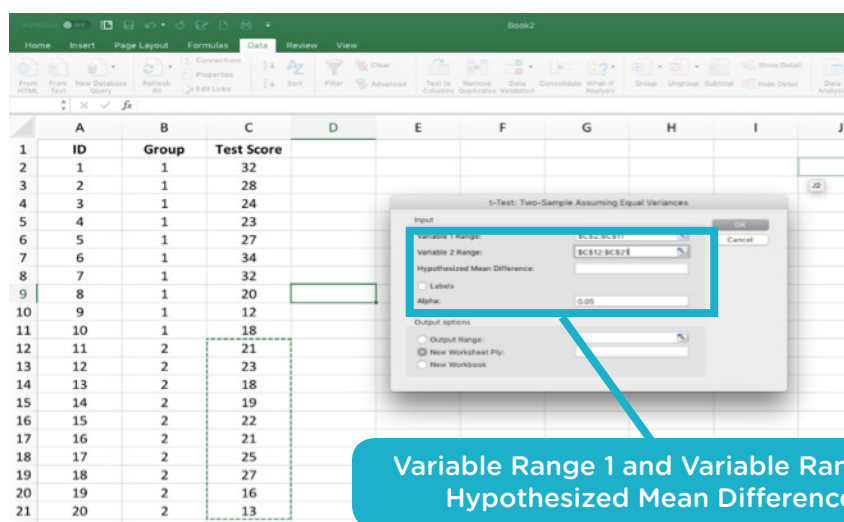

FIGURE --. Defining Data for Analysis

d After you have specified the values needed for the computation of the *t*-statistic, click **OK**. You will now see the results of your statistical test (Figure --). Unless you select otherwise, by default, the results will open in a new worksheet.
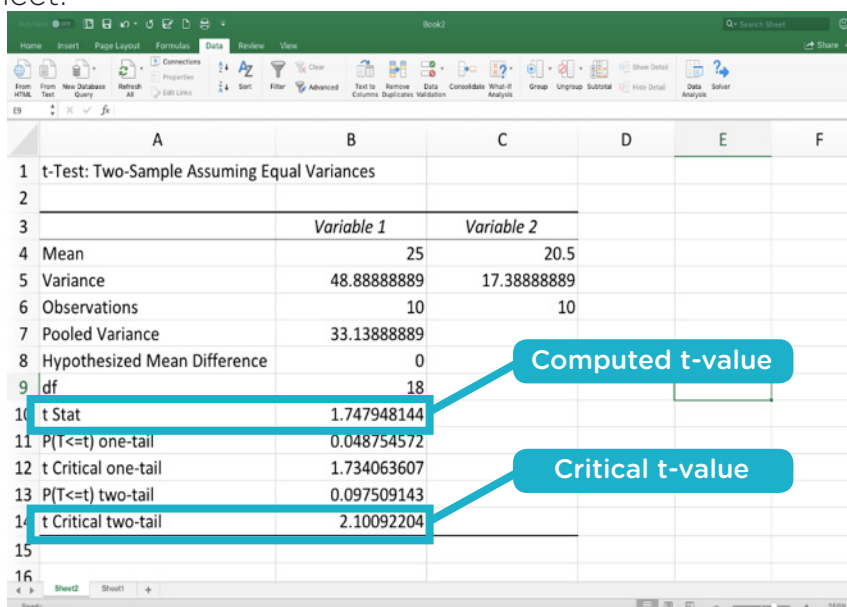
FIGURE --. Results of t-test

e From the MS Excel file, display the results as shown below.

TABLE --. Results of *t*-test

Group	Mean	SD	t computed		t critical	p-value
Experimental	2500	699	175		210	0.10
Control	20.50	417				

5 Compare the obtained or computed statistic with the critical value (or, the *p*-value associated with the obtained *t*-value and the alpha level).

Critical Value Approach	*p*-value Approach
REJECT THE NULL HYPOTHESIS IF the computed value is *greater than* the critical value.	REJECT THE NULL HYPOTHESIS IF the p-value is *less than* the alpha which is 0.05
t computed = 175 < *t* critical = 210	*p*-value = 0.10 > Alpha = 0.05

6 Decide on the null hypothesis.

Using the Critical Value Approach:
Since the computed *t*-value is *less* than the critical *t*-value, we *fail to reject* the null hypothesis.

Using the p-value Approach:
Since the *p*-value is *greater* than the alpha, we *fail* to reject the null hypothesis.

7 Draw the conclusion.

There is *no* difference between boys and girls in terms of scores on the manipulative test.

Put in another way:

Boys and girls do *not* differ with regard to scores on the manipulative test.

Suppose that the computed or obtained *t*-value happens to be *greater* than the critical *t*-value or that the *p*-value associated with the computed or obtained *t* is *less* than our alpha level of 0.05 What might be our conclusion? What can we say about boys and girls in terms of scores on the manipulative test? We can say that there is a difference between boys and girls and that boys do better than girls in the manipulative test.

Ask the participants if there are still questions regarding the topic Pause to respond to the questions. Keep your response as simple and as direct as possible. If questions are difficult to answer, simply explain that the answer to the question will be answered in subsequent LAC sessions.

Application (25 minutes)

Lead the participants as they put into practice what they have learned Say: "Now that we have discussed inferential statistics and shown how to use MS Excel Add-ins on our sample data, we are ready to apply what we have learned For this activity, you will be working in the same groups as earlier to encode data on pretest and posttest score of experimental and control groups. These data are intended for you to apply both independent *t*-test and paired *t*-test. Before encoding, prepare the coding guide first. Be sure to include the variables indicated in the data table. When you finish the coding guide, show it to me for confirmation. Then, encode the data following the coding guide. You may show me the data after encoding before proceeding with the data analysis.

For data analysis, first compute the descriptive statistics as we have been doing and then apply independent and paired t-tests on the data You should be able to determine which data points will require independent *t*-test and which ones will need paired *t*-test. If you have any questions, I would be glad to assist you.

I am providing not only the data sheet to be encoded but also the coding guide sheet as well as the report sheet. I would like you to follow the seven (7) steps of hypothesis testing as discussed for both the independent *t*-test and the paired *t*-test. Just a hint, data points for the same individuals may be displayed in consecutive columns as shown in the data sheet."

Distribute the following blank coding guide sheets and the data sheets to groups.

EXPERIMENTAL GROUP		CONTROL GROUP	
Pretest	Posttest	Pretest	Posttest
7	11	14	14
12	19	6	8
9	13	9	10
10	16	10	11
15	24	5	5
6	11	10	11
11	18	12	14
10	17	10	13
9	13	13	14
14	23	10	11
5	14	10	11
10	18	15	16
11	18	10	10
8	13	10	10
13	18	6	7

TABLE --. Coding Guide for Data Set

Column Number	Variable*	Variable Label*	Value	Value Label	Level of Measurement

TABLE --. Descriptive Statistics on Manipulative Test Scores of Boys and Girls

STATISTICS	GROUPS			
	Experimental		Control	
	Pretest	Posttest	Pretest	Posttest
Mode				
Median				
Mean				
Maximum				

Minimum				
Range				
Variance				
Standard Deviation				

TABLE --. Results of Independent t-test

	Mean	SD	t computed	t critical	p-value

TABLE --. Results of Paired t-tests

	Mean	SD	t computed	t critical	p-value

HYPOTHESIS TESTING

1. Research Question

2. Null and Research Hypotheses

3. Significance Level

4. Compute the statistic

   p-value associated with the statistic

5. Compare p-value with Alpha Level

6. Decide on the Null Hypothesis

7. Conclusion

Once the groups are done, a short reporting may be conducted for the benefit of everybody. Ask for group representatives to read reports or present them visually to the rest of the participants.

Closing (5 minutes)

End the learning session by saying: "Do you now know how to use inferential statistics to analyze data using MS Excel? Are there any questions?" Respond to any questions asked then proceed by saying: "Let me end today's LAC session by quoting the American children's book author, Dr. Seuss:

'The more you read, the more things you will know. The more you learn, the more places you'll go.'

—Dr. Seuss

Thank you for your active participation in today's LAC session. Goodbye and see you again soon."

POSTER OF DATA AND RESULTS
(to be posted for the task under *Activity*)

ID	BOYS	ID	GIRLS
B1	32	G1	21
B2	28	G2	23
B3	24	G3	18
B4	23	G4	19
B5	27	G5	22
B6	34	G6	21
B7	32	G7	25
B8	20	G8	27
B9	12	G9	16
B10	18	G10	13
Statistics			
Mode			
Median			
Mean			
Maximum			
Minimum			
Range			
Variance			
Standard Deviation			

Table 1: Critical values (percentiles) for the distribution.

The table entries are the critical values (percentiles) for the distribution. The column headed DF (degrees of freedom) gives the degrees of freedom for the values in that row. The columns are labeled by "Percent," "One-sided," and "Two-sided" Percent is distribution function; the table entry is the corresponding percentile. One-sided is the significance level for the one-sided upper critical value—the table entry is the critical value. Two-sided gives the two-sided significance level—the table entry is the corresponding two-sided critical value.

					Percent							
	75	90	95	975	99	995	9975	999	9995	99975	9999	99995
						One-sided						
	.25	.10	.05	.025	.01	.005	.0025	.001	.0005	.00025	.0001	.00005
						Two-sided						
	.50	.20	.10	.05	.02	.01	.005	.002	.001	.0005	.0002	.0001
df												
1	100	308	631	1271	3182	6366	12732	31831	63662	127324	318310	636620
2	.82	189	292	430	696	922	1409	2233	3160	4470	70.70	9999
3	.76	164	235	318	454	584	745	1021	1292	1633	2220	2800
4	.74	153	213	278	375	460	560	717	861	1031	1303	1554
5	.73	148	202	257	337	403	477	589	687	798	968	1118
6	.72	144	194	245	314	371	432	521	596	679	802	908
7	.71	142	190	237	300	350	403	479	541	608	706	788
8	.71	140	186	231	290	336	383	450	504	562	644	712
9	.70	138	183	226	282	325	369	430	478	529	601	659
10	.70	137	181	223	276	317	358	414	459	505	569	621
11	.70	136	180	220	272	311	350	403	444	486	545	592
12	.70	136	178	218	268	306	343	393	432	472	526	569
13	.69	135	177	216	265	301	337	385	422	460	511	551
14	.69	135	176	215	263	298	333	379	414	450	499	536
15	.69	134	175	213	260	295	329	373	407	442	488	524
16	.69	134	175	212	258	292	325	369	402	435	479	513
17	.69	133	174	211	257	290	322	365	397	429	471	504
18	.69	133	173	**210**	255	288	320	361	392	423	465	497
19	.69	133	173	209	254	286	317	358	388	419	459	490
20	.69	133	173	209	253	285	315	355	385	415	454	484
21	.69	132	172	208	252	283	314	353	382	411	449	478
22	.69	132	172	207	251	282	312	351	379	408	445	474
23	.68	132	171	207	250	281	310	349	377	405	442	469
24	.68	132	171	206	249	280	309	347	375	402	438	465
25	.68	132	171	206	249	279	308	345	373	400	435	462

TABLE --. Coding Guide for Data Set for Descriptive Statistics

Column Number	Variable*	Variable Label*	Value	Value Label	Level of Measurement
1	ID	ID NUMBER	as is		nominal
2	GROUP	GROUP	1	experimental	nominal
			2	control	
3	PRETEST	PRETEST SCORE	as is		ratio
4	POSTTEST	POSTTEST SCORE	as is		ratio

TABLE ---. Descriptive Statistics on Manipulative Test Scores of Boys and Girls

STATISTICS	GROUPS			
	Experimental		Control	
	Pretest	Posttest	Pretest	Posttest
Mode	1000	1800	1000	1100
Median	1000	1700	1000	1100
Mean	1000	1640	1000	1100
Maximum	1500	2400	1500	1600
Minimum	500	1100	500	500
Range	1000	1300	1000	1100
Variance	800	1554	800	857
Standard Deviation	283	394	283	293

TABLE --. Results of Independent t-test on Posttest

GROUPS	Mean	SD	t computed	t critical	p value
Experimental (n = 15	1640	394		205	
Control (n = 15)	1100	293			

TABLE --. Results of Paired t-tests

	Mean	SD	t computed	t critical	p value
Exp-Pretest	1000	283			
Exp-Posttest	1640	394			
Control-Pretest	1000	283			
Control-Posttest	1100	293			

HYPOTHESIS TESTING

1. Research Question
   A. Is there a difference between experimental and control groups in terms of posttest scores?
   B. Is there a difference between pretest and posttest scores of:
      1) experimental group
      2) control group

Note: The question on the control group is technically not necessary.

2. Null and Research Hypotheses
   A. Null Hypothesis: There is no difference between experimental and control groups in terms of posttest score.
      Research Hypothesis: There is a difference between experimental and control groups in terms of posttest scores.
   B1 Null Hypothesis: There is no difference between pretest and posttest scores of experimental group.
        Research Hypothesis: There is a difference between pretest and posttest scores of experimental group.
   B2 Null Hypothesis: There is no difference between pretest and posttest scores of control group.
        Research Hypothesis: There is a difference between pretest and posttest scores of control group.

Note: B2 is technically not necessary.

3. Significance Level
   Alpha for all hypotheses is α = 0.05

4. Compute the statistic
   A. *t* computed =   , *p*-value =
   B. *t* computed for Experimental Group =   , *p*-value =
      t computed for Control Group =   , *p*-value =

5. Compare *p*-value with Alpha Level
   A. *p* =
   B. *p* =
      p =

6. Decide on the Null Hypothesis
   A.
   B.

7. Conclusion
   A.
   B.

Prepared by:

JAERIEL R. BERSAMINA
Senior Education Program Specialist
Division of Abra
Department of Education–CAR

Edited by:

FE' JOSEFA G. NAVA, PhD
Consultant

Australian Aid

DepED
DEPARTMENT OF EDUCATION

BEST Basic Education
Sector Transformation

Cardno ACTRC PBEd PBSP BEST is supported by the Australian Government