Guardiola et al. 2010, Are statistics labs worth the effort?—Comparison of introductory statistics courses using different teaching methods. *Numeracy* 3(1). Appendices A – E.

APPENDIX A: SCENARIOS[1]

Scenarios are hypothetical problems that students are required to solve by applying previously learned material during the lecture session. These are examples of problem-based learning (PBL) and are conducive to learning by solving practically oriented problems. Below is a complete list of scenarios used in the lab section of Math 1442 for spring and summer (Treatment 1 and Treatment 2).

Contents

Scenario 1 (Lab Unit 1): Sample and Experimental Design
- The Scenario: Who is the Best Designing Team
- Lab 1 Minitab tutorial
- Examples from Minitab Manual

Scenario 2 (Lab Unit 2): Exploratory Data Analysis
- The Scenario: Statistical Help for Forensic Science
- Which Hand is Faster?
- The EDA Decision Roadmap
- Lab 2 Minitab tutorial
- Examples from Minitab manual

Scenario 3 (Lab Unit 3): Simulations and Probability
- The Scenario: Help for a Man on Trial
- Lab 3 timeline
- Lab 3 reference notes
- Two Handy Simulation Examples
- Lab 3 Minitab tutorial
- Lab 3 suggested grading rubric

Scenario 4 (Lab Unit 4): Exploring Normal Distributions
- The Scenario: Sports Statistics Help
- Lab 4 timeline
- Lab 4 reference notes
- Lab 4 Minitab tutorial
- Lab 4 suggested grading rubric

Scenario 5 (Lab Unit 5): Discovering Sampling Distributions (The Central Limit Theorem in Action)
- The Scenario: What is a Sampling Distribution?
- Lab 5 timeline
- Lab 5 reference notes
- Lab 5 "A Theorem in Discovery"

[1] Kindly provided by Champine (2006)

Lab 5 Minitab tutorial
Lab 5 suggested grading rubric

Scenario 6 (Lab Unit 6): Basic Statistical Inference
The Scenario: Your Dream Job
Lab 6 timeline
Lab 6 reference notes
Lab 6 Minitab tutorial
Lab 6 suggested grading rubric

Scenario 7 (Lab Unit 7): Linear Regression (modeling bivariate data)
The Scenario: Help for Mud Men
Lab 7 timeline
Lab 7 reference notes
Lab 7 Minitab tutorial
Lab 7 Data collecting sheets
Lab 7 Mud Report Thinking Questions
Lab 7 V-lab Write up Directions
Lab 7 suggested grading rubric

APPENDIX B: SCENARIOS EXAMPLES

Assigned to Treatment 1 and Treatment 2

Scenario 2

(a) To: You, the highly skilled statistical team

From: The local police department forensic science department

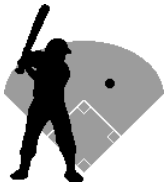
Your statistical team has been commissioned by your local police forensic science department. We found some bones believed to belong to a group of 4 young people that disappeared about a year ago. There is some evidence discovered at the scene that could point to murder. At the crime scene it has been determined that the remains are from three of the missing young people. The problem is that at the crime scene the bones are all jumbled up. In other words bones found near each other were not from the same individual. Location of the bones have been noted in detail, pictures have been taken, and now your help is required. Which of the four young people remains are these three likely to be? This is especially difficult since there are no skulls for dental records at the scene. Among the bones discovered was a full length left side tibia, a full length right side humerus, and a full length right side ulna. Each of these bones are believed to belong to a different individual. Of the four young people that went missing there was an 18 year old girl, a 23 year old girl, an 18 year old boy, and a 23 year old boy. It has not been determined yet which of these four individuals the remains of the three at the

crime scene belong to. We need you to do an exploratory data analysis. Your job is to take a random sample of a group of young people available for study measure their bone lengths, specifically the ones of interest, and explore the likelihood that the bones discovered came from one of the certain individuals that went missing. To expedite the process, multiple teams will be commissioned, so your team will be assigned one bone to investigate. Details about the specific bones found will be provided in detail at a later date. A full report is required within two weeks. We really need your help, we do not have any access to this type of information. Good luck and thank you for your services.

Scenario 4: Scenario 4: Sports Statistics Help

Assigned to Treatment 1 and Treatment 2






The sports broadcasting department of NCC network needs your help. We need to know if there is a regular mathematical pattern to several different sports statistics in order to help our broadcasters in the booth when they need something interesting to say. You are being hired to assess two of the sports statistics listed below. You are to look up these stats for every player during the last full year of completion of the particular sport. You are to look for an overall pattern in the distribution of these scores, especially to see if normal calculations can be used on each particular statistic for comparison purposes in the upcoming sports season. It is very helpful to the network sports statistics department to have a density curve of each statistic they plan to make comments about. It also helps to have percentile rankings for several players of varying abilities from the previous season for comparison purposes. We are excited to have you working with us and look forward to your findings. The list of statistics we need information about is as follows:

Baseball:	Batting averages
	Pitcher's ERA's
	Homerun totals
	On base percentage
Basketball:	Field goal percentage
	Free throw percentage
	Points per game average
Football:	Quarterback completion percentage
	Field goal percentage (kickers)

	Punting distance average
	Yard per rush (primary rushers)
Golf:	Greens in regulation percentage
	Fairways in regulation percentage
	Sand saves percentage
	Up and down percentage

Investigation of other sports statistics will be considered but must be approved by a network executive before research begins.

APPENDIX C: SELECTED QUESTIONS FROM FINAL EXAM

The Final exam administered to Control, Treatment 1 and Treatment 2 consists of 26 multiple choice questions and 4 essay type questions.

The multiple choice questions are taken from the test bank provided to instructors as supplemental material accompanying the textbook : Triola, M., *Elementary Statistics*, 10th Ed., 2006 (© 2006 by Pearson Education).

The essay type questions included in the exam are listed below;

27) The two most frequently used measures of central tendency are the mean and the median. Compare the two most frequently measures of central tendency for the following characteristics: Takes every score into account? Affected by extreme scores? Mention advantages and disadvantages of both central tendency measures. When do you prefer to use one or the other?

28) Define mutually exclusive events and independent events. Give an example of each. Explain the difference between them.

29) State the Central Limit Theorem (CLT). Describe the sampling distribution of the means for a population that is uniform and for a population that is normal. What are the requirements that you have to fulfill in order to be able to apply the central limit theorem?

30) Describe what regression is? Explain the purpose of regression.

APPENDIX D:
MODEL EQUATION AND DESCRIPTION OF VARIABLES

Full model equation:

*Final score = Treatment + Linguistic +Logical_Mathematical + Spatial + Bodily_Kinesthetic + Musical + Interpersonal + Intrapersonal + College + Level + Gender + Age + GPA + Attend + Treatment*College + Treatment*GPA + Treatment*Gender + College*GPA*

Description of variables used in the model equation (M.I.T. stands for Multiple Intelligence Test)

Final score = number of correct answers for the three exams administered during the semester expressed as a percentage of correct answers relative to the total number of questions (scale 0-100)
Treatment = indicator variable for "Control", "Treatment 1" or "Treatment 2"
Linguistic = m.i.t. score for linguistic intelligence (scale 1-12)
Logical_Mathematical = m.i.t. score for logical mathematical intelligence (scale 1-12)
Spatial = m.i.t score for spatial intelligence (scale 1-12)
Bodily_Kinesthetic = m.i.t score for bodily kinesthetic intelligence (scale 1-12)
Musical = m.i.t score for musical intelligence (scale 1-12)
Interpersonal = m.i.t score for interpersonal intelligence (scale 1-12)
Intrapersonal = m.i.t score for intrapersonal intelligence (scale 1-12)
College = Indicator variable for college coded as follows:
BUS = Business
EDU = Education
LA = Liberal Arts
NHS = Nursing and Health Sciences
ST = Science and Technology
Level = Indicator variable for class standing coded as follows:
FR = Freshman
SO = Sophomore
JR = Junior
SR = Senior
Gender = Indicator variable for gender coded as follows:
F = Female
M = Male
Age = Continuous variable for age
GPA = Continuous variable for grade point average (scale 0-4.0)
Attend = Continuous variable for percentage of attendance (scale 0-100)
Treatment College = Interaction term for Treatment and College*
*Treatment*GPA =Interaction term for Treatment and GPA*
*Treatment*Gender =Interaction term for Treatment and Gender*
*College*GPA =Interaction term for College and GPA*

Reduced model equation,

$$Final\ score = Treatment + College + GPA$$

APPENDIX E: SAS COMPUTER OUTPUT

The GLMSELECT Procedure

Data Set	WORK.STATSTUDY
Dependent Variable	Final
Selection Method	Backward
Select Criterion	SBC
Stop Criterion	SBC
Effect Hierarchy Enforced	None

Number of Observations Read	118
Number of Observations Used	91

The GLMSELECT Procedure

Class Level Information

Class	Levels	Values
TRT	3	0 1 2
Coll	5	BUS EDU LA NHS ST
Level	5	FR GM JR SO SR
Gender	2	F M

The GLMSELECT Procedure

Dimensions

Number of Effects	19
Number of Parameters	55

The GLMSELECT Procedure

Backward Selection Summary

Step	Effect Removed	Number Effects In	Number Parms In	SBC
0		19	38	505.3329
1	TRT*Coll	18	30	476.3202
2	GPA*Coll	17	26	462.8411
3	Level	16	22	450.6843
4	GPA*TRT	15	20	442.8980
5	TRT*Gender	14	18	434.9043
6	Spatial	13	17	430.4210
7	Age	12	16	425.9901
8	Log_Math	11	15	421.7339
9	Attend	10	14	417.9322
10	Musical	9	13	414.2014
11	Bod_Kine	8	12	410.5948
12	Gender	7	11	408.0836
13	Ling	6	10	405.2275
14	Intrapers	5	9	402.8117
15	Interpers	4	8	401.4429*

* Optimal Value Of Criterion

Selection stopped at a local minimum of the SBC criterion.

Stop Details

Candidate For	Effect	Candidate SBC		Compare SBC
Removal	TRT	410.1468	>	401.4429

The GLMSELECT Procedure
Selected Model

The selected model is the model at the last step (Step 15).

Effects: Intercept TRT Coll GPA

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value
Model	7	9382.81346	1340.40192	22.06
Error	83	5043.01978	60.75927	
Corrected Total	90	14426		

Root MSE	7.79482
Dependent Mean	64.46024
R-Square	0.6504
Adj R-Sq	0.6209
AIC	474.35598
AICC	476.57820
SBC	401.44285

The GLMSELECT Procedure
Selected Model

Parameter Estimates

Parameter		DF	Estimate	Standard Error	t Value
Intercept		1	29.168967	4.300049	6.78
TRT	0	1	-10.705168	2.537155	-4.22
TRT	1	1	-8.192404	2.815518	-2.91
TRT	2	0	0	.	.
Coll	BUS	1	5.602905	4.100415	1.37
Coll	EDU	1	-14.120338	3.235671	-4.36
Coll	LA	1	-15.223479	3.124711	-4.87
Coll	NHS	1	-5.252312	2.224367	-2.36
Coll	ST	0	0	.	.
GPA		1	16.024591	1.368663	11.71

The GLM Procedure

Class Level Information

Class	Levels	Values
TRT	3	0 1 2
Coll	5	BUS EDU LA NHS ST
Level	5	FR GM JR SO SR
Gender	2	F M

Number of Observations Read 118
Number of Observations Used 116

The GLM Procedure

Dependent Variable: Final

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	7	10970.38474	1567.19782	21.27	<.0001
Error	108	7959.18255	73.69613		
Corrected Total	115	18929.56728			

R-Square	Coeff Var	Root MSE	Final Mean
0.579537	13.47708	8.584645	63.69812

Overall Noncentrality

Min Var Unbiased Estimate	139.1
Low MSE Estimate	136.48
95% Confidence Limits	(87.297,210.62)

Proportion of Variation Accounted for

Eta-Square	0.58
Omega-Square	0.55

95% Confidence Limits (0.43,0.64)

Source	DF	Type I SS	Mean Square	F Value	Pr > F
TRT	2	917.621726	458.810863	6.23	0.0028
Coll	4	460.298178	115.074544	1.56	0.1898
GPA	1	9592.464834	9592.464834	130.16	<.0001

Noncentrality Parameter

Source	Min Var Unbiased Estimate	Low MSE Estimate	95% Confidence Limits	
TRT	10.22	10.03	1.6	29.4
Coll	2.13	2.09	0.0	16.1
GPA	126.75	124.36	79.4	192.4

The GLM Procedure

Dependent Variable: Final

Total Variation Accounted For

Source	Semipartial Eta-Square	Semipartial Omega-Square	Conservative 95% Confidence Limits	
TRT	0.0485	0.0405	0.0000	0.1332
Coll	0.0243	0.0087	0.0000	0.0693
GPA	0.5067	0.5009	0.3780	0.6009

Partial Variation Accounted For

Source	Partial Eta-Square	Partial Omega-Square	95% Confidence Limits	
TRT	0.1034	0.0827	0.0136	0.2023
Coll	0.0547	0.0190	0.0000	0.1216
GPA	0.5465	0.5268	0.4064	0.6239

Source	DF	Type III SS	Mean Square	F Value	Pr > F
TRT	2	902.648789	451.324394	6.12	0.0030
Coll	4	2364.876156	591.219039	8.02	<.0001
GPA	1	9592.464834	9592.464834	130.16	<.0001

Noncentrality Parameter

Source	Min Var Unbiased Estimate	Low MSE Estimate	95% Confidence Limits	
TRT	10.0	9.83	1.52	29.1
Coll	27.5	26.98	10.19	56.7
GPA	126.8	124.36	79.42	192.4

Total Variation Accounted For

Source	Semipartial Eta-Square	Semipartial Omega-Square	Conservative 95% Confidence Limits	
TRT	0.0477	0.0397	0.0000	0.1320
Coll	0.1249	0.1089	0.0141	0.2182
GPA	0.5067	0.5009	0.3780	0.6009

The GLM Procedure

Dependent Variable: Final

Partial Variation Accounted For

Source	Partial Eta-Square	Partial Omega-Square	95% Confidence Limits	
TRT	0.1019	0.0812	0.0129	0.2005
Coll	0.2291	0.1949	0.0807	0.3282
GPA	0.5465	0.5268	0.4064	0.6239

The GLM Procedure

Level of	Final		GPA		TRT
N	Mean	Std Dev	Mean	Std Dev	
0	75	64.2317548	12.6397648	2.86488000	0.67821630
1	25	59.0640000	10.5269844	2.83448000	0.62413267
2	16	68.4375000	15.3401814	2.75156250	0.61038326

The GLM Procedure
Least Squares Means
Adjustment for Multiple Comparisons: Tukey-Kramer

TRT	Final LSMEAN	LSMEAN Number
0	60.4760061	1
1	58.9686397	2
2	68.0959743	3

Least Squares Means for effect TRT
Pr > |t| for H0: LSMean(i)=LSMean(j)

Dependent Variable: Final

i/j	1	2	3
1		0.7662	0.0065
2	0.7662		0.0042
3	0.0065	0.0042	

TRT	Final LSMEAN	95% Confidence Limits	
0	60.476006	57.419096	63.532916
1	58.968640	55.106894	62.830385
2	68.095974	63.522105	72.669844

Least Squares Means for Effect TRT

i	j	Difference Between Means	Simultaneous 95% Confidence Limits for LSMean(i)-LSMean(j)	
1	2	1.507366	-3.637833	6.652566
1	3	-7.619968	-13.421390	-1.818547
2	3	-9.127335	-15.780349	-2.474320

The GLM Procedure
Least Squares Means
Adjustment for Multiple Comparisons: Tukey-Kramer

Coll	Final LSMEAN	LSMEAN Number
BUS	72.9491623	1
EDU	53.7447922	2
LA	54.5244496	3
NHS	63.6106022	4
ST	67.7386937	5

Least Squares Means for effect Coll
Pr > |t| for H0: LSMean(i)=LSMean(j)

Dependent Variable: Final

i/j	1	2	3	4	5
1		0.0065	0.0054	0.2694	0.7680
2	0.0065		0.9998	0.0730	0.0012
3	0.0054	0.9998		0.0575	0.0007
4	0.2694	0.0730	0.0575		0.2603
5	0.7680	0.0012	0.0007	0.2603	

Coll	Final LSMEAN	95% Confidence Limits	
BUS	72.949162	64.360291	81.538034
EDU	53.744792	47.018625	60.470959
LA	54.524450	48.974291	60.074608
NHS	63.610602	60.054721	67.166483
ST	67.738694	65.164969	70.312418

Least Squares Means for Effect Coll

i	j	Difference Between Means	Simultaneous 95% Confidence Limits for LSMean(i)-LSMean(j)	

1	2	19.204370	3.859655	34.549085
1	3	18.424713	3.942898	32.906527
1	4	9.338560	-3.566492	22.243612
1	5	5.210469	-7.138057	17.558994
2	3	-0.779657	-12.972113	11.412798
2	4	-9.865810	-20.296214	0.564594
2	5	-13.993902	-23.763052	-4.224751
3	4	-9.086153	-18.354457	0.182152

The GLM Procedure
Least Squares Means
Adjustment for Multiple Comparisons: Tukey-Kramer

Least Squares Means for Effect Coll

i	j	Difference Between Means	Simultaneous 95% Confidence Limits for LSMean(i)-LSMean(j)	
3	5	-13.214244	-22.100997	-4.327491
4	5	-4.128091	-9.778874	1.522691