Assessing Student Learning
in Introductory Statistics:
An Authentic Assessment Approach

ARTIST Roundtable Conference on Assessment in Statistics

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Background

I. Carnegie Foundation for the Advancement of Teaching and Learning
   A. 1997 Carnegie receives a grant from the Pew Charitable Trust to begin the Carnegie Scholars Program
   B. Goals of Program
      1. Foster significant, long-lasting learning for all students
      2. Enhance the practice and profession of teaching
      3. Bring to faculty members' work as teachers the recognition and reward afforded to other forms of scholarly work.

   C. K-12 and College/University Programs

II. Campus Conversations Program
  A. Over 200 campuses have signaled that they are working actively to foster the scholarship of teaching and learning by registering on the AAHE Web site at http://aahe.ital.utexas.edu/
  B. Leading institutions include Youngstown State University, Indiana University (Bloomington), Notre Dame University, Portland State University

III. Carnegie Scholar logistics
  A. Application process that involves the description of a SoTL project
  B. First class was June 1998
  C. My cohort began in June 2000 with 39 other scholars.
  D. Scholars program began again in June 2003 on liberal education
  E. Sponsored residencies in June, Jan and the following June

IV. Scholarly Teaching
  A. Attends conferences on teaching
  B. Develops innovative curriculum materials
  C. Makes those materials public through conference presentations or journal articles

V. Scholarship of Teaching and Learning (SoTL)
  A. Investigates the impact on student learning of innovative materials
  B. Asks the question, what have **my** student's learned?
  C. Redefines a "Teaching Problem" as an opportunity for understanding

VI. Fuzzy classification of SoTL (Taken from <u>Opening Lines</u> by Pat Hutchings)

> A. What works? – Seeking evidence about the relative effectiveness of different approaches. This is more classic, is teaching this way "better" than teaching another way.
>
> B. What Is? – A thorough description of a particular approach or intervention. Often involves trying to understand student perception of materials.
>
> C. Visions of the Possible – trying to understand how to bring students to a certain level of understanding or engagement of the subject matter
>
> D. New frameworks for shaping thought about practice. Building a theory on how an approach or innovation impacts student learning.
>
> E. Overlap. A research project in SOTL can contain several of these elements.

VII. Relationship with the Education Community
  A. SoTL as a bridge to education community
  B. Some view SoTL with alarm and dread with legitimate concerns
  C. Ethical issues involved in conducting research on "captive" students

My own journey

I.   Movement within statistics education to utilize

1. Real data
2. Technology
3. Collaborative learning
4. Writing

II. History of Projects

- Project Book
    - Chatterjee, S., Handcock, M. and Simonoff, J. (1995). A Casebook for a First Course in Statistics and Data Analysis, John Wiley & Sons, Inc., New York.
- Term Long Projects
- One trick ponies in text book
- Writing as part of General Education Requirement

- In response, I co-developed a sequence of four data projects investigating factors related to low birth weight (Holcomb and Ruffer, *TAS* 2000)

- Each team submits one project and it is graded 50% on writing and 50% statistics

Project #1: Data Summary

The data which is stored in the file **ncbirth1450.sav** is a sample of birth records taken by the North Carolina State Center for Health and Environmental Statistics. The data set represents a random sample of 1450 births from the state of North Carolina. Of particular interest will be incidents of low infant birth weight. Low birth weight has been associated with weaker development of many characteristics such as intelligence, coordination, strength, etc. Low birth weight is commonly defined as less than 2500 grams.

Variable Label	Description
sex	Sex of child (1=Male, 2=Female)
age	Age of mother
educ	Education level of mother
gest	Completed Weeks of Gestation
bwtgroup	birth weight (grams) group (0=500 or less, 1=500-1000,2=1001-1500, 3=1501-2000, 4=2001-2500, 5=2501-3000, 6=3001-3500, 7=3501-4000, 8=4001-4500, 9=4501 and over)
marital	Marital status (1=married, 2=not married)
plural	Number of children born of the pregnancy
totounc	Weight of child in total ounces
low	0=infant was not low birth weight 1=infant was low birth weight
smoke	0=mother did not smoke during pregnancy 1=mother did smoke during pregnancy
drankalc	0=mother does not consume alcohol during pregnancy 1=mother did consume alcohol during pregnancy

The goal of this assignment is to obtain summary statistics for the variables in the data set. This is an important activity of most statistical studies. In your report, clearly label all tables and when appropriate give the units of measure. The components of the assignment are given below. Be sure your presentation is clear and organized. The use of tables is required.

Perform a written summary of the variables above. This will include determining the mean, median, standard deviation, minimum, and maximum for the continuous variables. Also include a histogram of the continuous variables, describe the shape of the variables, and comment on whether the mean or median is a better measure of center.

The discrete variables will require creating a frequency table (recall a frequency table will give the number in each category and the percent in each category).

Comment on the results of the above analysis. This requires forming your own conclusions concerning the data. Comment on the results that are intriguing or surprising. One could also comment on results that confirmed or contradicted personal beliefs. Comment on what other type of variables you suspect may be related to birth weight and discuss how those variables would be measured. This paragraph must contain at least six sentences.

Homework Grading Rubric

Organization					
Clarity of Exposition	2	4	6	8	10
Layout	2	4	6	8	10
Mechanics					
Grammar	2	4	6	8	10
Spelling & Punctuation	1	2	3	4	5
Thoroughness	2	4	6	8	10
Professionalism & Style	1	2	3	4	5
Mathematical and Statistical Accuracy (50 points)					
Total Points(100 points maximum)					

We declare that each of the following group members actively contributed to the work handed in. We understand that each group member has the right to veto the signing of another group member who did not contribute to the completion of the assignment.

 Group Name:

_____

Group Members:

III. Project Topics
      1.   Summary Analysis
      2.   Probability
      3.   Hypothesis Testing
      4.   Correlation and Regression

IV. Question of Interest
- DO THESE PROJECTS WORK???
- Is this form of assessment fostering student learning?

V. Do they work at what?
- Students gaining valuable experience with real data

- Students acquiring communication skills by writing technical reports that summarize results clearly and concisely

- Students learning how to use statistical and word processing software as tools to solve problems and communicate results

- Students acquiring skills in working with others

- Students learning to apply appropriate methodology

- Basically, can students DO statistics when they leave my course??????????

VI. Evaluation Challenges

a. How would I compare a class with projects to a traditional class?

1. Would it be possible?
2. Would it be ethical?
3. Traditional Examinations do not have students actually 'do' statistical analysis
4. Can I test students from a traditionally taught course with a take home data analysis project when they have had no training on how to prepare such a project?
   - Painting metaphor

b. How does one evaluate team written projects for assessing student learning?

1. An important question across disciplines using collaborative projects
2. An important question across disciplines using writing projects

VII. Authentic Assessment

- ***The Assessment Challenge in Statistics Education,*** edited by Iddo Gal and Joan Garfield. 1997. Amsterdam: IOS Press.

- Colvin, S., and Vos, K., "Authentic Assessment Models for Statistics Education"

    i. "It [authentic assessment] claims to measure by direct means the student performance on tasks that are relevant to the student outside of the school setting."

    ii. Adapting to "outside of the intro class setting"

VIII.   Main Assessment Tool

- **Individual Take Home Mid-Term and Final Exams that requires students to**

  1. summarize the data
  2. visualize the data
  3. formulate hypotheses
  4. conjecture results
  5. formally test hypotheses
  6. write their results in a report

  - ❖ **GOAL: Determine what percentage of students are achieving a threshold of understanding of how to do a data analysis project.**

  - ❖ **Caveat:** Does not prove anything definitively

- Topics

    1. emu taste test comparing emu meat to beef and turkey
    2. first year college student nutrition study
    3. osteoporosis and bone mineral density
    4. calcium, phosphorus, and alkaline phosphatase levels

- 22 unique data sets for 35 students

- Students used same data set on Midterm and Final

- Grading Rubric was the same as the group projects

Exam II – Take Home

First Year College Student Nutrition Study

The data for your project comes from a nutritional study conducted at Youngstown State University during 1997-1998. Forty four subjects completed the study in which body measurements and nutrition data was collected at the beginning of the Fall semester and then again in the Spring semester. A portion of that data appears in the data file nutri1a.xls which is available at http://csuohio.edu/holcombj/mth147/exam2.htm Note that some variables may not be used for this assignment, but may be used for the take-home Final Examination.

Variable guide:

studynum	An identifying number to keep track of subjects
gender	0=male, 1=female
residenc	0=on-campus, 1=off-campus
athlete	0=non-athlete, 1=athlete
heightf	Height in cm in the Fall semester
weightf	Weight in kg in the Fall semester
weights	Weight in kg in the Spring semester
bmifall	Body Mass Index in the Fall semester
weightch	Change in Weight from Fall to Spring (weights-weightf)
wt10	0=no, 1=yes for weight change over 10lbs.
bmi25f	0=no, 1=yes, for bmi over 25 in the Fall

The main purpose of the study was to examine weight and nutrition characteristics in the college first year population. One the variables examined was the change in weight from the fall to the spring. The variable **weightch** above is a variable that indicates whether the student gained more than 10 lbs during the first year (**weightch=1)** or did not (**weightch=0**).

Body Mass Index is a variable that is calculated by taking the weight in kg and dividing by height squared (note height must be in meters). Generally a BMI between 20 and 25 is considered good. BMI is a variable that indicates a person might be at risk for potential obesity. It does not apply in all situations, since many athletes might have a high BMI index as a result of a great amount of muscle mass. For the Fall semester, the variable **bmi25f=1** indicates a student has a BMI over 25, and **bmi25f=0** indicates a person has a BMI 25 or less.

Begin your report by providing a summary of the discrete variables (raw numbers and percents), and a table summary of the continuous variables of **heightf**, **weightf**, and **bmifall** (5 number summary and histogram). Determine the shape of the histograms and comment on whether the mean or median is a better measure of center.

Create a 2x2 contingency table of **athlete** vs. **wt10**. Let A be the event of being an athlete and B be the event of gaining 10 or more pounds during the first year. Determine the following:

1. P(A)   2. P(B)   3. P(A∩B)   4. P(A∪B)

5. P(B|A)   6. P(B|A′)

Now we will consider not being an athlete (A′) as a risk factor and gaining more than ten pounds as the disease (B). Calculate the relative risk and interpret its meaning.

Create a 2x2 contingency table of **athlete** vs. **bmi25f**. Let A be the event of being an athlete and B be the event of having a BMI over 25 during the fall semester. Determine the following:

1. P(B)   2. P(A∩B)   3. P(A∪B)

4. P(B|A)   5. P(B|A′)

Now we will consider being an athlete (A) [note the change from above] as a risk factor and having a BMI greater than 25 the disease (B). Calculate the relative risk and interpret its meaning.

Write a summary paragraph of at least five sentences that reports any of the findings that you find interesting or surprising. Also propose two additional variables that could have been measured with this study and describe how the measurement would have taken place.

Take Home Midterm Scores

```
 5|3
 5|
 6|
 6|
 7|24
 7|9
 8|1133
 8|5677
 9|0000011222344
 9|555557889
10|0
```

5|3=53 and 10|0=100

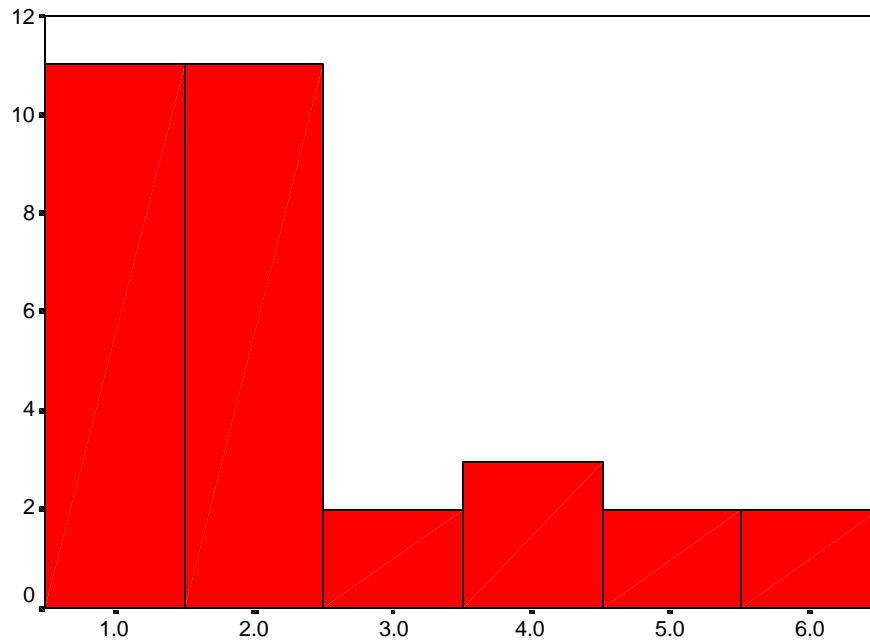❖ Have 31/35 (88.6%) achieving a score of 80 or better

Take Home Final Results

```
 6|0
 6|5
 7|
 7|8
 8|000124
 8|5667899
 9|1124
 9|55566677889
10|00
```
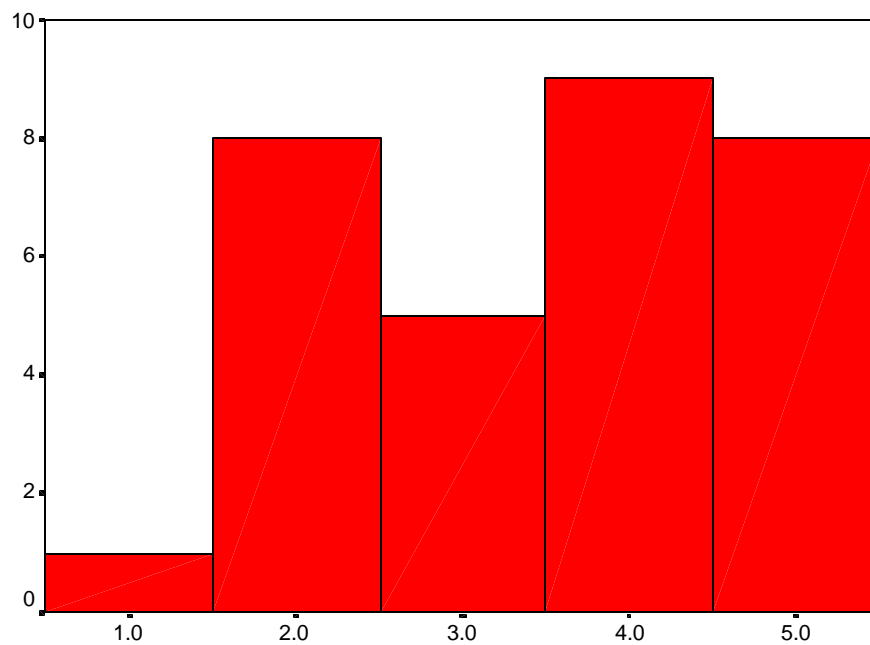
6|0=60 and 10|0=100

Two students earned 0's.

❖ 30 of 35 students (86%) earned a score of 80 or better.
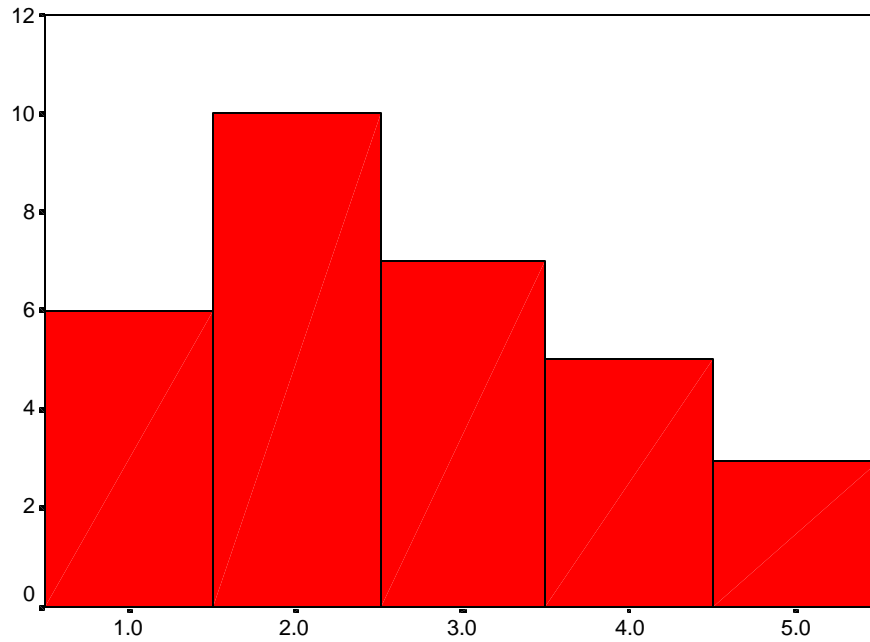
IX. Interesting Survey Results (31 Respondents)

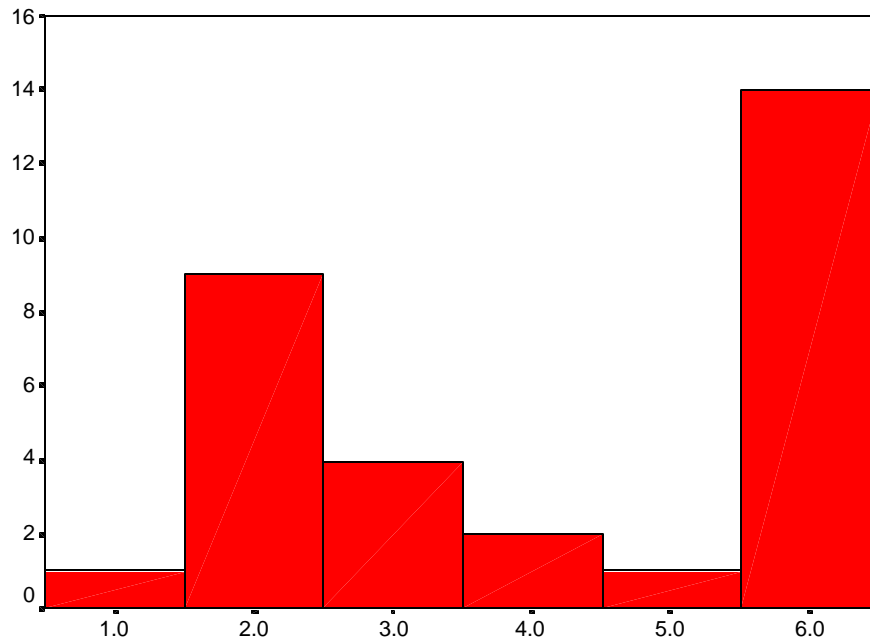

Team Projects adqueately prepared for Midterm

Take-home exam was too difficult

1=Strongly Agree   2=Mildly Agree 3=No opinion
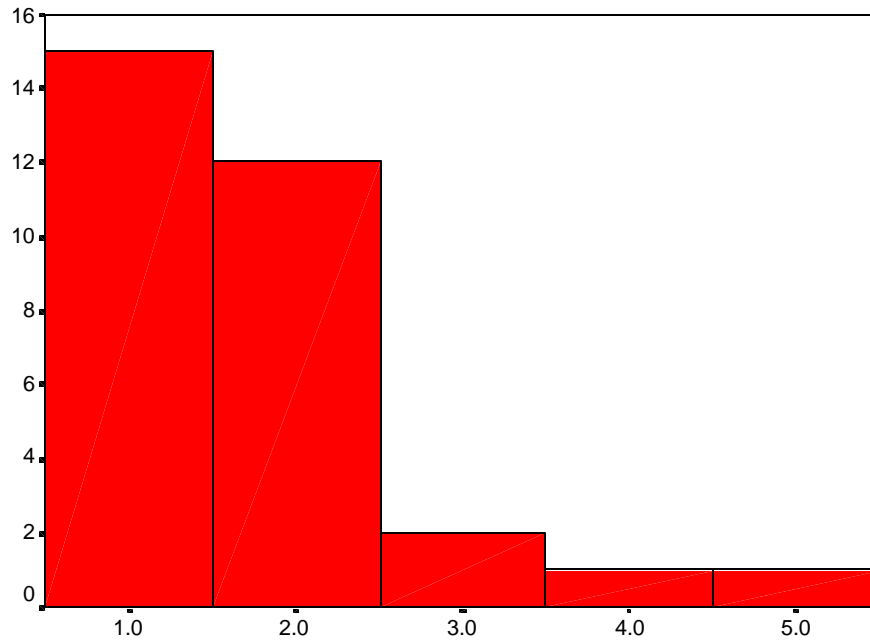4=Mildly Disagree   5=Strongly Disagree

I found making time to work with my team very difficult
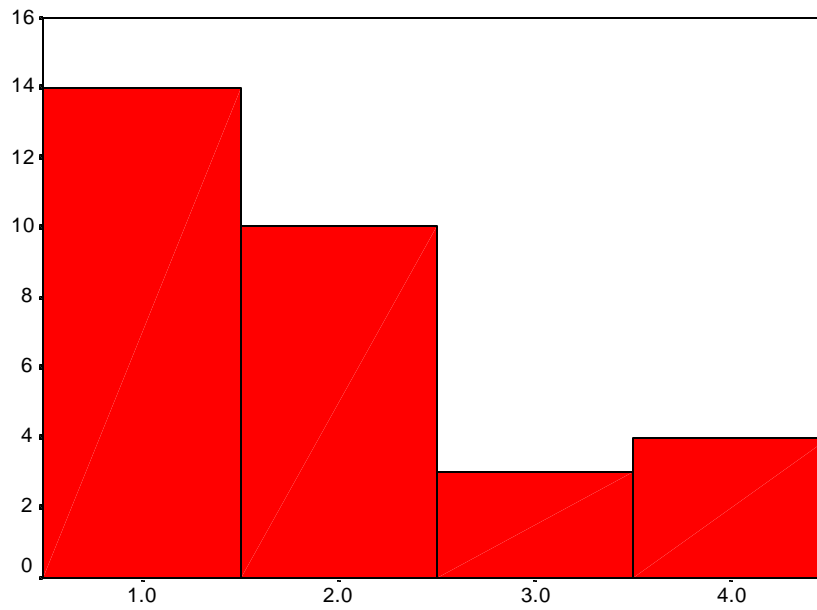

Working on projects prepared me for future team work

1=Strongly Agree   2=Mildly Agree 3=No opinion
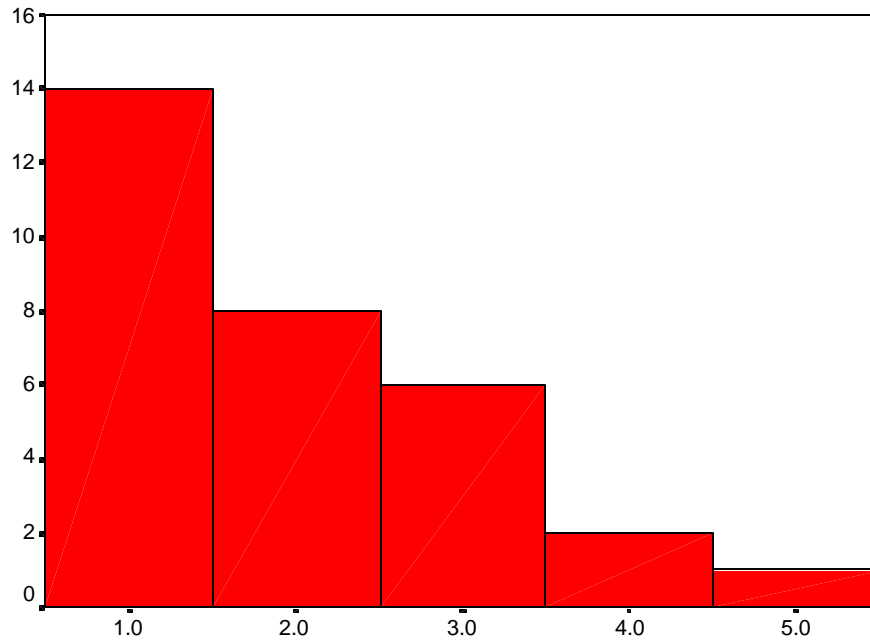4=Mildly Disagree   5=Strongly Disagree

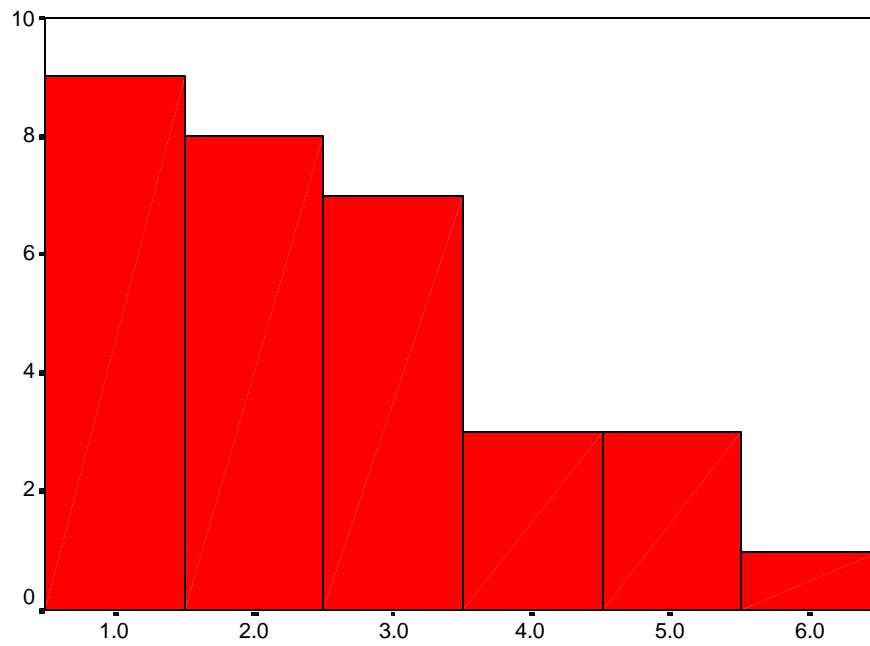Confident to do a summary analysis

Confident to do a regression analysis

1=Strongly Agree   2=Mildly Agree 3=No opinion
4=Mildly Disagree   5=Strongly Disagree

Can write a satisfactory data report for another course

The Projects will help me in my major and/or career

1=Strongly Agree   2=Mildly Agree 3=No opinion
     4=Mildly Disagree   5=Strongly Disagree

X. Future

- Redo Study
    - Use 5-6 data sets so that each person in each team has a different data set
    - A colleague with a Ph.D. in education is also going to grade the projects with the rubric
    - Each student will submit their reports electronically
- Write paper for journal submission

Take-Home Data Sets and Exams

http://academic.csuohio.edu/holcombj/projects/exams.htm

Zipped file of all files on this web page.

nutri1.xls	nutri2.xls	nutri3.xls	nutri4.xls	nutri5.xls	nutri6.xls
osteo1.xls	osteo2.xls	osteo3.xls	osteo4.xls	osteo5.xls	osteo6.xls
emu1.xls	emu2.xls	emu3.xls	emu4.xls	emu.xls	emu6.xls
ranges1.xls		ranges2.xls		ranges3.xls	

nutri1.mtw	nutri2.mtw	nutri3.mtw	nutri4.mtw	nutri5.mtw	nutri6.mtw
osteo1.mtw	osteo2.mtw	osteo3.mtw	osteo4.mtw	osteo5.mtw	osteo6.mtw
emu1.mtw	emu2.mtw	emu3.mtw	emu4.mtw	emu5.mtw	emu6.mtw
ranges1.mtw		ranges2.mtw		ranges3.mtw	

Take-home Midterm Exams (with Answers)

nutri1.doc	nutri2.doc	nutri3.doc	nutri4.doc	nutri5.doc	nutri6.doc
osteo1.doc	osteo2.doc	osteo3.doc	osteo4.doc	osteo5.doc	osteo6.doc
emu1.doc	emu2.doc	emu3.doc	emu4.doc	emu5.doc	emu6.doc
ranges1.doc		ranges2.doc		ranges3.doc	

nutri1.pdf	nutri2.pdf	nutri3.pdf	nutri4.pdf	nutri5.pdf	nutri6.pdf
osteo1.pdf	osteo2.pdf	osteo3.pdf	osteo4.pdf	osteo5.pdf	osteo6.pdf
emu1.pdf	emu2.pdf	emu3.pdf	emu4.pdf	emu5.pdf	emu6.pdf
ranges1.pdf		ranges2.pdf		ranges3.pdf	

Take Home Final Exams (with Answers)

nutri1_fin.doc	nutri2_fin.doc	nutri3_fin.doc	nutri4_fin.doc	nutri5_fin.doc	nutri6_fin.doc
osteo1_fin.doc	osteo2_fin.doc	osteo3_fin.doc	osteo4_fin.doc	osteo5_fin.doc	osteo6_fin.doc
emu1_fin.doc	emu2_fin.doc	emu3_fin.doc	emu4_fin.doc	emu5_fin.doc	emu6_fin.doc
ranges1_fin.doc		ranges2_fin.doc		ranges3_fin.doc	

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nutri1_fin.pdf	nutri2_fin.pdf	nutri3_fin.pdf	nutri4_fin.pdf	nutri5_fin.pdf	nutri6_fin.pdf
osteo1_fin.pdf	osteo2_fin.pdf	osteo3_fin.pdf	osteo4_fin.pdf	osteo5_fin.pdf	osteo6_fin.pdf
emu1_fin.pdf	emu2_fin.pdf	emu3_fin.pdf	emu4_fin.pdf	emu5_fin.pdf	emu6_fin.pdf
ranges1_fin.pdf		ranges2_fin.pdf		ranges3_fin.pdf	

References/Resources

Holcomb, J. and Ruffer, R. (2000). Using a term-long project sequence in introductory statistics, *The American Statistician*, 54, 49-53.

Scholarship Reconsidered: Priorities of the Professoriate, by Ernest L. Boyer. San Francisco: Jossey-Bass, Inc., 1990.

Opening Lines: Approaches to the Scholarship of Teaching and Learning

Edited by Pat Hutchings. Menlo Park, CA: The Carnegie Foundation for the Advancement of Teaching, 2000.
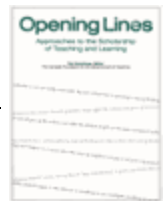
Ethics of Inquiry, Issues in the Scholarship of Teaching and Learning

Edited by Pat Hutchings. Menlo Park, CA: The Carnegie Foundation for the Advancement of Teaching, 2002.

Disciplinary Styles in the Scholarship of Teaching and Learning: Exploring Common Ground

Edited by Mary Taylor Huber and Sherwyn Morreale. Washington, D.C.:American Association for Higher Education and The Carnegie Foundation for the Advancement of Teaching, 2002.

http://www.carnegiefoundation.org/publications/

AAHE Web Center for Campus Conversations
http://aahe.ital.utexas.edu/