Sample Lesson Plan 1

Civil Engineering 305  Dr. S. Olani Durrant
Properties of Materials  Brigham Young University

Lecture 4--The Statistical Nature of Test Data

(Students have completed within the week uniaxial tests of steel, cast iron, and brass. They are seated in the classroom by lab group and have been asked to bring their test data and results.)

1. Pre-assessment (5 minutes)
   • Inquire if there are any questions on past week's lab work.
   • Have each lab group report their modulus of elasticity for steel. Record on board.

2. Motivation (Quadrant 1- WHY?) (5 minutes)
   • Higher order questioning
     Why are there differences among the various laboratory results?
     Why didn't anyone have steel specimen with the "standard" modulus? etc.

3. Illustrated Lecture (Quadrant 2 - WHAT?) (15 minutes)
   • Note sources of experimental error.
     (Page 50 of manual)
   • Review statistical relationships.
     (Page 51 of manual)
   • Introduce bell curve and the relationships of standard deviations.
     (Bell curve - see attached figure)
   • Distribute reduced test data for 19 brass specimens.
     (Test data for 19 brass specimens - see Table A)
   • Discuss mean and standard deviation for each property shown.
   • Show histogram/bell curve plot for 19 values of ultimate strength.
     (Histogram/bell curve - see attached figure)
   • Review and ask for questions.

4. Student Practice (Quadrant 3 - HOW?) (15 minutes)
   • Distribute copies of bell curve/histogram.
   • Ask each group to add their data for brass to the previous 19 and calculate new values for mean and standard deviation for each property.
   • Have each group plot the values from their lab on the bell curve/histogram.

LEARNING ASSESSMENT
   • Have a representative from each group come to overhead projector and add the value of ultimate strength for their lab specimen.
   • Review concepts and correct any misunderstandings (shift back to Quadrant 2 as necessary to clarify concepts).

5. Applying (Quadrant 4 - WHAT IF?) (10 minutes)
   • Point out that 98% of all values fall between plus or minus 2.33 standard deviations.
"What if you were to use this brass for a tension member and you wanted to guarantee 99% success against fracture?"

**Think time and wait for responses**

"What would be your maximum stress?"

"Translate that into a factor of safety on the mean value."

"What are the problems with this design?"

"What factor of safety do you want?"

"Does that guarantee zero failures?"

"What is the probability?"

Continue as appropriate and as time allows.


<table>
<thead>
<tr>
<th>Specimen Number</th>
<th>Modulus of Elasticity (ksi)</th>
<th>.2% Offset Yield Stress (ksi)</th>
<th>Ultimate Strength (ksi)</th>
<th>Ductility (% Elongation in 2&quot;)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>13900</td>
<td>43.6</td>
<td>56</td>
<td>20.5</td>
</tr>
<tr>
<td>2</td>
<td>14300</td>
<td>53.8</td>
<td>61.2</td>
<td>19</td>
</tr>
<tr>
<td>3</td>
<td>15300</td>
<td>45.7</td>
<td>59.3</td>
<td>22.5</td>
</tr>
<tr>
<td>4</td>
<td>14000</td>
<td>50</td>
<td>56.1</td>
<td>25</td>
</tr>
<tr>
<td>5</td>
<td>11600</td>
<td>43.5</td>
<td>54.9</td>
<td>36.5</td>
</tr>
<tr>
<td>6</td>
<td>13000</td>
<td>43.4</td>
<td>55</td>
<td>18.7</td>
</tr>
<tr>
<td>7</td>
<td>14400</td>
<td>44.3</td>
<td>56.8</td>
<td>19.8</td>
</tr>
<tr>
<td>8</td>
<td>13400</td>
<td>51.2</td>
<td>57.7</td>
<td>15.8</td>
</tr>
<tr>
<td>9</td>
<td>13900</td>
<td>47.1</td>
<td>55.7</td>
<td>16.3</td>
</tr>
<tr>
<td>10</td>
<td>14100</td>
<td>41.8</td>
<td>53.9</td>
<td>17.8</td>
</tr>
<tr>
<td>11</td>
<td>13200</td>
<td>42.2</td>
<td>54.6</td>
<td>23.6</td>
</tr>
<tr>
<td>12</td>
<td>10000</td>
<td>48</td>
<td>57.8</td>
<td>15.3</td>
</tr>
<tr>
<td>13</td>
<td>15700</td>
<td>46.7</td>
<td>60.4</td>
<td>29.7</td>
</tr>
<tr>
<td>14</td>
<td>15400</td>
<td>45.9</td>
<td>58.8</td>
<td>23.8</td>
</tr>
<tr>
<td>15</td>
<td>12700</td>
<td>51.4</td>
<td>58.8</td>
<td>15.8</td>
</tr>
<tr>
<td>16</td>
<td>13400</td>
<td>42.8</td>
<td>55</td>
<td>21.5</td>
</tr>
<tr>
<td>17</td>
<td>15500</td>
<td>53.1</td>
<td>63.2</td>
<td>20</td>
</tr>
<tr>
<td>18</td>
<td>13400</td>
<td>50.5</td>
<td>60.4</td>
<td>12.5</td>
</tr>
<tr>
<td>19</td>
<td>13300</td>
<td>42.2</td>
<td>55.5</td>
<td>22</td>
</tr>
<tr>
<td>Mean</td>
<td>13711</td>
<td>46.7</td>
<td>57.4</td>
<td>20.8</td>
</tr>
<tr>
<td>Smpl.Std.Dev.</td>
<td>1377</td>
<td>3.9</td>
<td>2.6</td>
<td>5.5</td>
</tr>
<tr>
<td>Coeff. of Var.</td>
<td>10.0</td>
<td>8.4</td>
<td>4.5</td>
<td>26.6</td>
</tr>
</tbody>
</table>
Figure 1. Normal Curve of Error

Figure 2. Histogram/bell curve plot for 19 values of ultimate $\xi$
Sample Lesson Plan 2

Chemical Engineering 436
Process Control and Dynamics
Dr. Ronald E. Terry
Brigham Young University

The following lesson plan uses activities from each of the quadrants to teach the concept of tuning a feedback control loop. The figure at the end of the lesson outline shows the activities in the 4MAT system.

Concept to be taught: Tuning a feedback control loop.

1. Quadrant one activity

   Higher order questioning.

   Why is it important for a controller to be carefully tuned?
   Based on previous discussion of feedback loops, etc., what information do you feel is necessary to tune a loop?

2. Quadrant two activity

   Formal lecture coupled with instructor worked example problems.

   Various tuning methods are presented and discussed.

3. Quadrant three activity

   Homework problems and laboratory assignment of a carefully outlined and working experiment.

   Application of tuning methods are presented in homework problems followed by an experiment in the Chemical Engineering unit operations laboratory. The experiment uses a carefully outlined procedure, which has been previously checked for errors, involving one of the methods discussed in the quadrant two activity. The procedure has been designed to give the students hands on experience with a control loop that is known to work and provide good control.

4. Quadrant four activity

   Open-ended laboratory assignment.

   In this lab assignment, the students are asked to use two or more of the tuning techniques discussed in the quadrant two activity to tune the loop. They are then asked to make a judgment of the quality of the control obtained with their techniques and discuss the results.
CONCEPT: TUNING A FEEDBACK CONTROL LOOP
Sample Lesson Plan 3

Construction Management 210
Framing Methods

Dr. Loren Martin
Brigham Young University

Topic: Estimating Procedures for Framing Materials

Quadrant 1 Why?  Class Discussion

Why is it important to develop accurate estimating procedures?

What potential problems may be associated with a poor estimation?

Personal Experience

Relate a personal experience which illustrates the importance of accurate bidding procedures.

Quadrant 2 (What?): Lecture

Provide formal instruction regarding estimating procedures for framing materials.

Quadrant 3 (How?): Lab/Activity

Students had previously worked together in groups of three as part of a lab section to construct a scale model of a house. Assign students to make estimates of materials and labor for floor framing, wall framing, and roof framing of the house. This assignment may be performed individually or as groups.

Quadrant 4 (What if?): Simulation

Students from the various work groups are re-assigned to a different work group of three students so that none of the previous partners are working together. They are to assume that they are a framing subcontracting company and are assigned to submit a bid for the framing of the house, including framing and sheathing materials, labor, and profit.

The reason that the groups are divided differently is so that each student is required to defend his/her original estimates. The group must then come to a consensus on the estimate and determine the bid price. All bids are called for at a predetermined time and are compared by writing them on the chalkboard. A discussion is held after this activity concerning actual bid-day practices and the necessity of being very accurate in estimating and bidding procedures so that you can develop as low a bid as possible and still be able to earn a profit if the contract is awarded to you.

This activity is usually performed during a two-hour lab section. It typically a very realistic experience with high student interest and interaction. The importance of teamwork and accuracy are emphasized.
Sample Lesson Plan 4

Electrical and Computer Engineering 220
Digital State Machines
Dr. Gene A. Ware
Brigham Young University

Class 5 - Gates and Mixed Logic.
(The students have covered number systems and basic Boolean algebra.)

1. **Review** (5 minutes)
   a. Questions on assigned homework.
   b. Questions on Boolean algebra.

2. **Why?** (Quadrant 1) (5 minutes)
   a. Story of fatal F-16 flight when pilot attempted to "climb" over his target when in low level, inverted flight.
   
   b. You (the student) are asked to design a warning light which will light when the pilot is in inverted flight below a minimum altitude.
   
   c. The sensors and light control are TTL compatible. The inverted flight sensor and the low altitude sensor produce a low voltage when in inverted flight and at low altitude, respectively, and a high voltage otherwise. The warning light is lit when a low voltage is applied. Only an "OR" gate is available for the logic.
   
   d. Ask the students how to design this simple problem using the given device. Some will see the negative logic solution. Initiate a discussion on designing with both positive and negative logic called mixed logic design.

3. **What?** (Quadrant 2) (20 minutes)
   a. Using an interactive, question based lecture, develop the following diagram on the board.

<table>
<thead>
<tr>
<th>Boolean World</th>
<th>Hardware World</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Boolean Values 0,1</td>
<td>1. Voltages - high, low</td>
</tr>
<tr>
<td>2. Boolean Variables</td>
<td>2. Hardware signals</td>
</tr>
<tr>
<td>3. Boolean Equations</td>
<td>3. Logic is performed by hardware</td>
</tr>
<tr>
<td>4. Truth Tables</td>
<td>4. Function Tables</td>
</tr>
<tr>
<td>5. K-Maps</td>
<td></td>
</tr>
</tbody>
</table>

   Define: Asserted = 1  Not Asserted = 0
b. Questions which could be asked include:
- What is in the Boolean world? (Boolean zeros, Boolean ones, Boolean variables, Boolean equations, truth tables, K-maps, etc.)
- What is in the hardware world? (Hardware devices, integrated circuits, gates, voltage measurements, device function tables, etc.)
- Boolean world: Can you hold a Boolean one? Can you measure a Boolean one with a meter? Can you measure a voltage in the Boolean world?
- Hardware world: Can you hold a piece of hardware (a gate chip, for example)? Can you measure a Boolean one with a meter? Can you measure a voltage in the hardware world?

c. Include the idea that Boolean algebra is conceptual and is used as a theoretical tool in the design and modeling of digital circuits just as the calculus is used as a theoretical tool for modeling the physical world around us.

d. The Boolean world speaks a language of zeros and ones. The hardware world (TTL, at least) speaks a language of high and low voltages. A translation rule is needed to relate the two worlds.

e. Defining the word "asserted" to mean one in the Boolean world, define the asserted-low (1-low) and asserted-high (1-high) translation rules.

f. Show how this translation works with the so-called "OR" gate.

<table>
<thead>
<tr>
<th>Boolean &quot;OR&quot;</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 0</td>
<td>0</td>
</tr>
<tr>
<td>0 1</td>
<td>1</td>
</tr>
<tr>
<td>1 0</td>
<td>1</td>
</tr>
<tr>
<td>1 1</td>
<td>1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Boolean &quot;AND&quot;</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 0</td>
<td>0</td>
</tr>
<tr>
<td>0 1</td>
<td>1</td>
</tr>
<tr>
<td>1 0</td>
<td>1</td>
</tr>
<tr>
<td>1 1</td>
<td>1</td>
</tr>
</tbody>
</table>

TRUTH TABLES
(Boolean)

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>0</td>
<td>1</td>
<td>1</td>
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<tr>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

FUNCTION TABLE
(Hardware)

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>L</td>
</tr>
<tr>
<td>0</td>
<td>1</td>
<td>H</td>
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<tr>
<td>1</td>
<td>0</td>
<td>H</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>H</td>
</tr>
</tbody>
</table>

Asserted-High
(High Voltage = 1)

Asserted-Low
(Low Voltage = 1)
4. How (Quadrant 3) (10 minutes)
   a. Ask for seven student volunteers. Arrange them as follows:

<table>
<thead>
<tr>
<th>Boolean Inputs</th>
<th>Input Translators</th>
<th>Hardware Gate</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>A, B</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

   b. The A and B Boolean input students are given large cards with a "0" on one side and a "1" on the other side. The A and B input translators are given large cards with a "L" on one side and a "H" on the other side. The hardware gate student (the only one with any logic) is given a large "L" and "H" card. The output translator is given a large "0" and "1" card. The seventh student serves as a scribe to record the results.

c. The input translators translate the input Boolean values into voltages. The output translator translates the gate output voltage into a Boolean value. Instruct the hardware gate to perform the hardware operation defined by the function table for the "OR" gate (which is listed on the board for reference) based on the voltages displayed by the input translators.

d. Instruct all translators to use the asserted-high (1-high) translation rule. Walk the Boolean inputs through the four possible input combinations and record the results in a truth table on the board.

e. Instruct all translators to use the asserted-low (1-low) translation rule. Instruct the gate to perform according to the same function table. Walk the Boolean inputs through the four possible input combinations and record the results on the board.

f. Compare the two truth tables (Boolean world) obtained from the function table (hardware world) by using the two translation rules. The asserted-high rule causes the "OR" gate to perform the Boolean "OR" operation. The asserted-low rule causes the same "OR" gate to perform the Boolean "AND" operation. Note that a similar condition holds for the "AND", "NAND" and "NOR" gates.

g. Observe that the F-16 design problem can be solved by using the "OR" gate with the asserted-low translation rule which matches the voltage specification of the sensors and the warning light.
5. **What If?** (Quadrant 4) (10 minutes)

   a. Give the students a handout containing the function tables for two input "AND", "OR", "NAND" and "NOR" gates. Stress that these names do not define the Boolean operation performed by the gate. This will be determined by the translation rule to be used.

   b. As a homework assignment, have the students ask **What If** the following assignments were made (i.e., what Boolean functions are performed):

      - The inputs to each gate were asserted-high and the output was asserted-high.
      - The inputs to each gate were asserted-high and output was asserted low.
      - The inputs to each gate were asserted-low and the output was asserted high.
      - The inputs to each gate were asserted-low and the output was asserted low.
      - What changes if one input is asserted-high and the other input is asserted-low?

6. **Summary and Conclusions**
Sample Lesson Plan 5

Manufacturing Engineering 232  
Manufacturing Processes  
Dr. Robert H. Todd  
Brigham Young University

The following brief lesson plan outlines activities from each of the four learning quadrants intended to help students learn the importance of considering design for manufacturability of a device in the early stages of design.

1. Quadrant one activity: (Why?)
   - Socratic or higher order questioning
     - Why is it important to consider manufacturability as well as functionality in the early stages of the design process of a device or product?
     - Why is the designer responsible for these considerations?
     - Who else is responsible and why?

2. Quadrant two activity: (What?)
   - Formal lecture including review of cost sources in manufacturing
     - How the total cost of manufacturing is divided up, design, materials, labor, burden, etc.
     - The cost of engineering changes from concept selection to final production. The rule of 10’s.
     - Review check lists of features that can be designed into a product to improve manufacturability.

3. Quadrant three activity: (How?)
   - Reverse engineering case study
     - Review design features of an inexpensive simple consumer device that make manufacturability easy or difficult.
     - How could the existing design be changed to improve its manufacturability, cost, quickness to market, quality, etc?

4. Quadrant four activity: (What if?)
   - Reverse engineering team assignment
     - Suppose you are assigned to work with a team of employees to reverse engineer a competitor's product and improve the manufacturability of the product by altering the products design. What would you do and why, using information you have learned?  
        Student team picks product and does redesign.
SUMMARY OF QUADRANT ACTIVITIES FOR SAMPLE LESSON PLAN 5