# Analysis of Results in SOTL Projects

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# What aspect do you want to measure?

- **Content:** calculus, functions, proofs
- **Cognition:** problem solving, misconceptions
- **Psychological Factors:** motivation, affect, visualization
- **Teaching Methods:** lecturing, cooperative learning, uses of technology, uses of writing
- **Culture:** gender, equity, surrounding culture, cross-cultural comparison

# Collecting Data

**Who:** about whom we record some characteristic.
respondents – people who answer a survey
subjects – people on whom we experiment

**What:** variable measured – grade, confidence level, attitude, graduate school (categorical and quantitative)

**Why:** why are you collecting the data?

**When:** when do you want to collect the data (pre, post, during)?

**Where:** where do you collect your data?

**How:** how do you collect your data

# The Valid Survey

**What do I want to know?** What do you hope to learn and about whom you hope to learn it.

**Am I asking the right respondents?** Have you identified an appropriate sample frame. Do you know the population of interest and are you sampling from it appropriately?

**Am I asking the right questions?** What would I do with the answer to this question if I got it?

**Ask for quantitative results when possible:** how many hours per week did you study?

# Classroom Assessment

A straightforward, learner-centered, teacher-directed approach that makes use of assessment to improve the effectiveness of higher education where it matters most: in the college classroom.

# What is a statistically easy question to analyze?

- Student scores on exams by year in school, major, gender, ACT score, etc.
  - regression, chi-square tests
- Student gains on an exam as measured by scores on a pre and post test.
  - paired data analysis

# What is a statistically difficult question to analyze?

Do my efforts in the use of collaborative groups to teach first semester Calculus increase the likelihood that a student will take the second semester?

There are lurking variables galore here.  Variability among classes, among semesters, instructors, students – to control for all this is practically impossible within our mission to educate.

# What can we do?

To establish causation is a real stickler here.

- We can certainly measure the number of students who went on to a second course last year, when we didn't use cooperative groups and compare that to this year, when we did.
- But, these other factors would prevent us from attributing this effect to this one particular factor – the use of cooperative groups.

# Can we change the question so that the statistical analysis becomes more tractable?

- We could give a pre and post simple question: Do you plan to take Calculus II?
- Teach two sections – one uses collaborative groups and the other does not.

# It’s not perfect.

- There are clearly plenty of lurking variables remaining – student abilities, your effectiveness as an instructor at the two times the class is taught.
- The numbers are likely going to be small, and not statistically significant.

# Identifying the population

- Statistics definition
- Example: Considering the population to be *all* students leaves us with a “non-random” sample. What can we do?
  - Select a random or stratified sample from the population of all students. (Impractical)
  - Reconsider the population definition.
  - If want departmental inference, need to get some collaborative effort among instructors teaching the course of interest.
  - Another level yet – different universities.

# What is a statistically impossible question to analyze?

Asking students to write or speak about their experiences in a course can be very valuable for an instructor in determining effective instructional strategies.

- Information can be loosely sorted and summarized, but quantitative analysis is next to impossible.
- But everything useful doesn’t have to “generalize.”

# Common Analysis Methods

- Very important: *when* is a particular method suggested?
  - Data types
  - Visualization options
  - Example: Two Calculus I sections

    Record the variable values: *Year*, *Gender*, *School*, *ACT*, *HSrank*, *Background*, *CourseGrade* , *Groups*, *ContinuePre*, *Pretest*, *ContinuePost, Posttest, Change*

# 1. Test or interval for proportions

- Compare or test proportions of an outcome of interest, for samples from one or two groups
  - Data: count data
  - Visuals: split bar chart
  - Example: compare proportions of each *Gender* who plan to continue on to Calculus II

# 2. Chi-square test for independence

- Look for an association (dependence) between row and column variables
  - Data: count data, in two categorical variables
  - Visuals: cross-tabulation of counts, by row and column variables
  - Example: determine if *Gender* distribution is associated with *School*

# 3. Regression

- Determine if there is <u>linear</u> dependence of a response variable on one or more "predictor" variables
  - <u>Data</u>: two (or more) variables measured on same individuals; typically numeric
  - <u>Visuals</u>: scatter plot with regression line; residual plot
  - <u>Example</u>: use *ACT* to predict *CourseGrade*
  - <u>Comments</u>: very flexible method; variations can incorporate categorical predictors or response

# 4. Test or interval for means

- Compare or test averages of an outcome of interest, for samples from one or two groups
  - Data: numeric, average makes sense
  - Visuals: histogram; boxplot
  - Example: compare mean *ACT* between males and females (*Gender*)

# 5. Paired test for means

- Determine if there is a difference in a numeric response before to after some treatment.
  - Data: numeric data, measured on the same (or matched) individuals
  - Visuals: histogram; boxplot of differences
  - Example: calculate *Posttest – Pretest* and test for an increase in score

# 6. ANOVA / Factor Analysis

- Compare means across levels of one or more factors
  - Data: numeric data observed for several groups, between which we want to make a comparison
  - Visuals: interaction plot of means or medians
  - Example: compare *ACT* across levels of *Gender* and *School*

# 7. Nonparametric

- Tests which can be used without underlying distributional assumptions; typically less efficient and less powerful
  - Data: various; one commonly used method is testing numeric data which cannot be assumed to come from a “normal” distribution
  - Visuals: varies
  - Example: “sign test” of *Posttest – Pretest* to test for an increase in score, when sample is small with outliers

# Concluding Example

- Answer question (revised to appropriate population): "From among all students who would take Calculus I from me, is the proportion who change their minds to move on to Calculus II higher for the group work section(s) than for the individual work section(s)?"

# Results

- Truth: in population, proportion switching is 0.35 with *Group* = Y and 0.12 with *Group* = N.
- Samples: note that we only get to see the first.

| Sample | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| Proportion from *Group* = Y | 0.311 | 0.378 | 0.386 | 0.370 | 0.333 | 0.556 | 0.258 | 0.424 |
| Proportion from *Group* = N | 0.143 | 0.050 | 0.118 | 0.100 | 0.045 | 0.158 | 0.256 | 0.098 |

# Observed results

- From sample 1, we observe the following counts:

| | ***Change*** **= Y** | ***Change*** **= N** | |
|---|---|---|---|
| ***Group*** **= Y** | 14 | 31 | **45** |
| ***Group*** **= N** | 5 | 30 | **35** |
| | **19** | **61** | **80** |

What procedure should we use to test if the percent of students who change differs when groups are used?

# Results

- **“Minitab” output for a Chi-square test for independence**

```
          C1      C2  Total
    1      14      31      45
        10.69   34.31
        1.027   0.320

    2       5      30      35
         8.31   26.69
        1.320   0.411

Total      19      61      80

Chi-Sq = 3.078, DF = 1, P-Value = 0.079
```

- **Vital to make conclusions for the *appropriate* population**