Authentic Discovery Projects in Elementary Statistics

A. Robb Sinn
Dianna J. Spence
Karen S. Briggs
North Georgia College & State University

7th Annual Interdisciplinary Conference for Teachers of Undergraduates
Teaching Matters: Engaging Approaches
March 27-28, Gordon College

Agenda

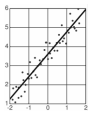
- Dianna
  - Overview
  - Interdisciplinary Project Ideas
  - Measuring Effectiveness
- Robb
  - How to Implement Projects in Course
  - Project Materials Developed
- Karen
  - Perspectives from Faculty Adopting Project Materials

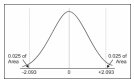
Framework: Statistics Education Research

National Science Foundation
WHERE DISCOVERIES BEGIN

- Supported by NSF Grant: "*Authentic, Career-Specific Discovery Learning Projects in Introductory Statistics*"
- Goals: Increase students'
  - knowledge & comprehension of statistics
  - perceived usefulness of statistics
  - self-beliefs about ability to use and understand statistics

Discovery Projects





- Linear regression
  - Variables
    - student selects
    - often survey based constructs
  - Survey design
  - Sampling
  - Regression analysis
- *t*-tests
  - Variables
    - may borrow from data previously collected
  - Designs
    - Independent samples
    - Dependent samples
  - Hypotheses

Authentic Research Constructs

- Interdisciplinary Team
  - Biology/Ecology
  - Criminal Justice
  - Psychology
  - Sociology

  - Health Professions (Nursing, Physical Therapy)
  - Education
  - Business
- Tasks of Team Members
  - Identify quantitative research constructs
  - Define instrument/measurement of construct
  - Suggest simple statistical research projects

Constructs and Projects: Psychology

- Screening instruments (avoid diagnostic)
  - Construct examples
    - Perceived stress
    - Perfectionism
    - Depression
    - Alcohol abuse
    - Anxiety
    - Obsessive Compulsive (OCD)
    - Attention Deficit/Hyperactivity (ADHD)
  - Sample projects
    - regression: relationship between 2 scores (e.g., stress and perfectionism); or with another quantitative variable (e.g., age)
    - *t*-tests: compare scores between groups (e.g., by gender, between 2 ethnic groups, between rural/urban)

Constructs and Projects: Sociology (I)

- Attitude toward social issues
  - Ex: corporal punishment, homosexuality, abortion
  - Quantitative: numeric Likert style responses
  - Categorical: favor/oppose
  - Sample projects
    - regression: relationship between 2 ratings or between 1 rating and another quantitative variable (e.g., relationship between age and attitude toward corporal punishment)
    - *t*-tests: 1) compare ratings between groups (e.g., by gender) or 2) compare other attributes between favoring/opposing groups (e.g., age, other quantified attitude variable)

Constructs and Projects: Sociology (II)

- Attitude toward women
  - Multi-item questionnaire
    - Likert style responses
    - Overall numeric score
    - Sample items:
      - *A woman should not work if her husband is capable of supporting the family*
      - *Women are not suited to serve in the armed forces*
  - Sample projects
    - regression: relationship between score and another quantitative variable (e.g., age or other attitude variable)
    - *t*-tests: compare scores between groups (e.g., by gender, between 2 ethnic groups, between rural/urban)

Constructs and Projects: Sociology (III)

- Race Issues
  - Multi-item questionnaire
    - Likert style responses
    - Overall numeric score
    - Sample item
      - *I would be comfortable if my close relative were planning to marry someone of another race.*
  - Sample projects
    - regression: relationship between score and another quantitative variable (e.g., age or other attitude variable)
    - *t*-tests: compare scores between groups (e.g., by gender, between 2 ethnic groups, between rural/urban)

Constructs and Projects: Biology/Ecology (I)

- Trash generation
  - e.g., measure by weighing trash daily for 1 week
  - Sample projects
    - regression: trends by age?
    - *t*-test: compare trash generated by two groups (e.g., gender, urban/rural, ecology/non-ecology majors)
- Lichen growth as indicator of air quality
  - documented instructions for measuring growth
  - Sample projects
    - *t*-test: compare wooded areas in rural/suburban regions

Constructs and Projects: Biology/Ecology (II)

- Assessment of environmental risks
  - Examples: global warming, nuclear power, pesticides, burning fossil fuels, smoking, firearms
  - Participants rank their perception of risk (e.g., on a 1 – 10 scale)
  - Sample projects
    - *t*-tests: compare ratings among groups (e.g., gender, urban/rural, ecology/non-ecology majors)

Constructs and Projects: Biology/Ecology (III)

- Attitude toward environmental issues
  - Examples: importance of recycling, importance of energy conservation
  - Participants rate perceived importance (e.g., on a 1 – 10 scale)
  - Sample projects
    - regression: relationship between any 2 ratings (e.g., attitude toward recycling vs. toward conservation)
    - *t*-tests: 1) independent – compare among groups or 2) dependent – survey before and after ecology course

Constructs and Projects: Criminal Justice

- Attitude toward criminal justice issues
  - Examples: death penalty, gun control, pornography, legalization of marijuana, legal drinking age
  - Quantitative: numeric Likert style response
  - Categorical: favor vs. oppose
  - Sample projects
    - regression: relationship between any 2 ratings (e.g., attitude toward death penalty vs. toward gun control)
    - *t*-tests: 1) compare ratings between groups (e.g., by gender) or 2) compare other attributes between favoring/opposing groups (e.g., age, other quantified attitude variable)

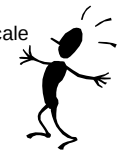
Pilot Study

- Based on 10 sections of Introductory Stats
- 4 experimental sections
  - Used authentic discovery projects
  - n=113 participants out of 128 students
    - 88% participation rate
- 6 control sections
  - Did not use authentic discovery projects
  - n = 164 participants out of 192 students
    - 85% participation rate

Pilot Results: Content Knowledge

- Instrument
  - 21 multiple choice items
  - KR-20 analysis: score = 0.63
- Results
  - control mean: 8.87; experimental mean = 10.82
  - experimental mean 9 percentage points higher
  - experimental group significantly higher ($p < .0001$)
  - effect size = 0.59

Pilot Results: Perceived Usefulness of Statistics



- Instrument
  - 12-item Likert style survey; 6-point scale
  - 5 items reverse scored
  - score is average (1 – 6) of all items
  - Cronbach alpha = 0.93
- Results
  - control mean: 4.24; experimental mean = 4.51
  - experimental group significantly higher ($p < .01$)
  - effect size = 0.295

Pilot Results: Statistics Self-Beliefs

- Beliefs in ability to use and understand statistics
- Instrument
  - 15-item Likert style survey; 6-point scale
  - score is average (1 – 6) of all items
  - Cronbach alpha = 0.95
- Results
  - control mean: 4.70; experimental mean = 4.82
  - difference not significant (1-tailed $p = .1045$)
  - effect size = 0.15

Full Study (In Progress)

- 3 institutions
  - 1 university
  - 1 2-year college
  - 1 high school
- 7 instructors
  - Multiple sections per instructor
- Quasi-Experimental Design
  - All instructors teach “control” sections first
  - Same instructors then teach “experimental” sections

Origins of Authentic Discovery

- First idea: Spring ’04
- Initial pilot work
- NSF Grant
  - If at first you don’t succeed…
  - Funded in May ’07

Methods

- Required collaborative project
  - Linear Regression (n = 100)
    - Compare 3 numeric variables
    - Report findings
      - Class presentations
      - Written report
- Required final project
  - T-tests or group comparisons
    - May work in teams of 1, 2, 3 or 4
    - Written report only

Materials

- Instructional materials development project
  - Student guides (50+ pages)
    - Project guide
    - Technology guide
    - Variables and constructs guide
  - Instructor guides (100+ pages)
    - Student materials info
    - Assignment sheets
    - Rubrics, score sheets and peer evaluation sheets
- View our instructional materials at:
  - http://radar.ngcsu.edu/~rsinn/nsf

Drawbacks

- Team meltdowns
  - They do happen
  - Tips & suggestions
- Time: Some instructional time must be sacrificed
  - The big time cost isn’t grading, it’s evaluating early portions of the project and helping students develop quality research topics and reasonable surveys
- Students attitudes
  - Some students (usually good ones) loathe, detest and despise group work

Benefits

- Learning Outcomes
- Classroom energy and atmosphere
- Office hours
- Professional development opportunities

Set Their Expectations Early

“The main thing that we have learned is that statistics take time. They cannot be conjured up by a few formulas in a few minutes. The time and effort that is put into a small research project such as this is significant. On a large scale, one can quickly understand the kind of commitment of money and time that is required just to obtain reasonable data.”

“When we started the project, we were unaware of how much time we would have to put into it.”

Little to No Correlation is OK

"While our results did not meet our initial expectations, this is not an utter disappointment. Before this project, statistics looked simple enough for anyone to sit down and do, but now it is evident that it requires more creativity and critical thinking than initially expected. Overall, it was an edifying experience."

Creating Good Surveys Isn't Easy

"Statistics are not easy to acquire. The amount of time to produce an unbiased survey that correctly analyzes the question of the study is hard."

"One of the most important facts we have learned in these past weeks is that statistics can be horribly confusing and increasingly more difficult to put together a formidable survey. We tried hard to assemble the best survey possible in order to have the most accurate results, but after the surveys were gathered it became easy to see the difficulties we had overlooked."

"From there we created our survey. This was the hardest part of the entire experience because in order for any research project to be viable in the end, it requires a good base to start on."

Use Available Resources

"*Our team learned many things that will aid us in finding and analyzing statistical information in the future. Our team also has a better understanding of how to use Excel in analyzing data. This statistical project was very informative and will help us show how exercising is a proven stress reliever*."

"The resources that helped us the most were computer programs like Excel and Word. Also, the print shop was a big help in getting our surveys printed out. We really were not lacking in any of our resources."

Encourage Teamwork

"*We all really enjoyed this project though some parts were tough. I think it was a chance to really work as a team and accomplish a lot. This project has taught me to really communicate with team members and get things done on a schedule. It has been a learning experience for all of us*."

It Really Works

"We now know how statistics can actually be used in real life. There are so many mathematics classes that you sit through and think, 'I am never going to use this information in my life.' Statistics is helpful and can be used by anybody on any day."

"*Months ago when a member of our group saw a survey on television we may have wondered how in the world someone could spend their lives administering surveys. However, after living through the experience ourselves we truly understand how complex and intricate the surveying process can become. The experience we have gained collecting our own survey has been enlightening and gave us a greater respect for the statistical community*."