Teaching statistics students to be collaborative statisticians

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Exercise

- Please take a sheet and in writing,

1. Explain to a non-statistician adult researcher what is a '**significant p-value**'
2. Explain to a non-statistician adult researcher what is meant by '**interaction**' in statistics
3. Explain to a non-statistician adult researcher what is a '**mixed-effects linear model**'

- Hand your answers to a colleague !

Introduction

- Teaching statistics
  - how to teach statistical concepts to non-statisticians – with age-appropriate approaches
  - how to teach statistical theory and methods to future statisticians
  - how we teach future young statisticians to be professional statisticians
- Formal post-graduate degree programs
  - teach students the theory of statistical science
  - teach students the methodologies ("tool kit") needed to be practicing statisticians
- What is missing: how to work as a professional statistician in collaborative settings with non-statisticians

Objective

- Present how the Department of Biostatistics of the University of North Carolina trains our masters and doctoral students to 'be statisticians.'
  - Graduates go to academia, government and private organizations

Background

- The Department of Biostatistics of the University of North Carolina was established in 1949
  - Within a School of Public Health
  - Within 'Allied Health'

  → Colleagues are non-statisticians

Curriculum – formal coursework

Masters

- **Required basic courses**
  - Statistical software
  - Probability & inference
  - Intermediate analysis methods
  - Linear models
  - Longitudinal data analysis
  - Survival analysis
- **Intermediate and Advanced Statistics**
  - 2 electives
- **Supporting program**
  - Public health courses
- ***Practicum***

Doctoral

- **Required basic courses**
  - Statistical software
  - Probability & inference
  - Intermediate analysis methods
  - Linear models
  - Sampling
- **Required advanced courses**
  - Advanced probability and statistical inference
  - Theory of linear models
  - Generalized linear models
  - Longitudinal data analysis
  - Survival analysis
- **Advanced Statistics**
  - 4 electives
- **Supporting program**
  - Public Health courses
- ***Practicum***

Methods – *Practicum* & courses

- Individual mentored experiences with a faculty member doing applied work as a **g**raduate **r**esearch **a**ssistant (GRA)
  - students are placed in a research institute setting with other statisticians and non-statistician investigators
- Leadership course
- Capstone course – "Statistical Consultation"
  - communication skills (written & oral)
  - ethics of the profession
  - other practical skills for being a 'practicing statistician'

Methods - GRA

- Experiences may include
  - Theoretical work
  - Practice-based methodological development
  - Routine project-related work
  - Varying mentorship
  - Leadership experience
- Experience is not standardized/uniform

Methods – Leadership course

- The course is divided into the following four modules:
  1. Broad leadership concepts (e.g., vision, culture, strategic thinking, communication, motivation)
  2. Management skills (e.g., delegation, decisionmaking/analysis, project management)
  3. Leadership styles (personal, team, and organizational)
  4. Guest leader presentations (leadership stories and class problemsolving)
- Not required, not all take it!

AMSTATNEWS
The Membership Magazine of the American Statistical Association
1 February 2012

Leadership in Biostatistics students at The University of North Carolina. From left: Margaret Polinkovsky, Alison Wise, Jennifer Clark, Beth Jablonski Horton, Annie Green Howard, and Michael Hussey.

Methods – Statistical Consultation course

- Required course for ALL graduating masters and doctoral students
- Topics - No new methodology!
- Products:
  - Statistical Analysis Plan
  - Statistical Report
  - Statistical Considerations section for a grant proposal
  - Statistical Methods section of a collaborative scientific publication
- Stress is on communication – written, oral, non-verbal
- Special topics
  - Ethics of the discipline
  - Leadership as statistician

In most formal statistics courses

- Students do not have to 'translate' a non-statisticians' research question into a statistical question
- Students do not communicate orally
- Homework
  - Usually does not require choosing the method to answer the question
  - The answer is read by a statistician!

→ Students have a hard time

- Integrating methods
- **Not** using statistical jargon

Statistical Consultation course approach

- 'Lectures'
- Project-based learning
  - Real-situation-based learning
- In-class activity-based learning
  - Small-group-based interactions
  - Impromptu 'spur-of-the-moment' communication exercises
- Apprenticeship learning
  - 'Shadowing' faculty as they consult through the departmental consultation service
- Homework
  - Presented orally in class with review by other students!

Methods – Statistical Consultation course

- 'Lecture' topics
  - Effective verbal and non-verbal communication
  - Effective use of diagrams, tables and graphs
  - Ethics of being a statistician
  - Elements of standard statistical products [statistical analysis plans, statistical reports, methods section in a manuscript, statistical sections for grant proposals]
  - Sample size & power in planning research studies
  - Elements of data management and quality assurance systems [data management plan]
  - Statisticians as reviewers of research by others [proposals, manuscripts, data & safety monitoring boards]
  - Statisticians as leaders in collaborative work

Methods – Statistical Consultation course

- Project work
  1. Must develop a 'statistical analysis plan', execute it, and write a report for a course-chosen non-statistician investigator with a typically 'messy' complex real dataset and/or a complex real research question
  2. Must write the 'Statistical considerations' sections for an actual grant proposal that is to be submitted by a course-chosen non-statistician researcher
  3. Must do #1 or #2 above for a student-chosen non-statistician researcher

Methods – Statistical Consultation course

- In-class activities
  - Individual oral and written 'spur-of-the moment' non-technical explanations of simple and complex statistical issues
    - E.g. interaction
    - E.g. 95% confidence interval
    - E.g. mixed-effects linear model

  - Small group discussion followed by oral presentation
    - 'Case studies' on ethical issues
    - Ways to present data – text, graphs, tables
    - Writing the statistical reply to peer-review comments on a manuscript

Methods – Statistical Consultation course

- In-class activities - example
  - Writing the statistical reply to peer-review comments on a manuscript

In-class Exercise – Writing statistical sections of collaborative manuscripts

Scenario: You are the only statistician co-author on a collaborative manuscript. The manuscript was submitted to a scientific journal, and after the peer review, the Editor gives a "Conditional Acceptance" subject to addressing the various questions and comments of the reviewers. The first author addresses the non-statistical questions and comments, but asks you to address the following statistical question/comment made by one of the reviewers. Your response must be brief and to the point, and you can assume that a statistician or someone with methodological expertise will look at your response. Thus, you must statistically justify your response.

Methods – Statistical Consultation course

- In-class activities – small-group sessions

Methods – Statistical Consultation course

- Apprenticeship learning
  - The Biostatistics Department provides a consultation service for researchers in allied health – part of our participation in the Translational and Clinical Sciences (TraCS) Institute of our university
  - Drop-in consultation hours is one service provided
  - Students must sign-up for a session, but faculty provides consultation
  - Student must write-up description of the consultation process, not the statistical content of it

Methods – Statistical Consultation course

- Homework - examples
  1. Reviewing the Statistical Considerations section of published manuscripts
  2. Small data-analysis project – presented as a research question – e.g. honeybees

Honey Bee Graph Assignment - due Wednesday 16 January 2008

Below is the problem description for the "honey bee" problem – mortality as a by-product to insecticide sprays. This was initially assigned as a major consulting problem several years ago. Your assignment is to examine the problem and the data and then construct one page (and only one page) with one (or more) key graphs which illustrate the major findings of this research in terms of the questions given on page 3, especially questions 1, 3, 4, and 5. Write one paragraph explaining your graph(s) on a separate piece of paper. Bring your graphical summary to class on **Wednesday January 16**. Your work for this assignment may be hand written, but it must be legible.

Age-appropriate activities

- Young persons enjoy learning with group activities
- Activities that generate data and then analyzing their own data
- Age-appropriate activities
  - Primary school – games & candy
  - Middle & high school – sampling & collecting data
  - University – experimentation
  - Graduate students - ??

Extra-curricular 'fun' activities

AWOL Activity #1: Data collection

We will be tasting 4 wines – A,B,C,D – all are NC or VA chambourcin. The order of the labels is randomized separately for each taster. The taster can taste the wines in any order desired. Taster must:

i. assign scores to each wine using the international scoring system below
ii. total the score for each wine
iii. provide an overall preference rank to each wine, from 1 for best to 4 for worst (separate from the total point score)
iv. for each wine, provide a guess as to whether the wine is expensive or not expensive

Please complete the following information

- Sex: ☐ Male ☐ Female
- Age group: ☐ > 35 years old ☐ ≤ 30 years old, BUT > 21 years old
- Normally, I prefer to drink: ☐ white wines ☐ red wines

Extra-curricular 'fun' activities

AWOL Activity #2: Kendall's coefficient of concordance

According to Chapter 6 of Kendall (1948) Rank Correlation Methods, Griffin & Company, Ltd., London, when we have m rankings of n (=4 in our case) objects, we may be interested in the concordance among the rankers/tasters in this case.

The sum of all rankings is mn(n+1)/2, and under the null hypothesis that the wines are NOT different (i.e. there is no preferred ordering), the expected value of the sum of rankings for each wine is m(n+1)/2. If S is the sum of squares of the actual deviations of the observed sums of rankings from the expected sum of rankings, then Kendall defined as the coefficient of concordance:

$$W = \frac{12S}{m^2(n^3-n)},$$

which ranges from 0 if no concordance to 1 for perfect concordance. The exact distribution of the W statistic can be obtained by Fisher's permutation principle and enumerating all $(n!)^m$ possible sets of ranks.

Exercise: Calculate how concordant are the tasters tonight!

Extra-curricular 'fun' activities

AWOL Activity #3: Friedman's test

The U.S. economist Milton Friedman proposed a test [Friedman (1940) A comparison of alternative tests of significance for the problem of *m* rankings. *The Annals of Mathematical Statistics* **11** (1): 86–92] related to the parametric repeated measures ANOVA but based on ranks, to detect differences in treatments (wines) across multiple experiments (tasters). He proposed the following statistic:

$$Q = \frac{nS}{SS_e},$$

where SS_e is the residual or error sums of squares from the repeated measures ANOVA of ranks. The exact distribution can be obtained by Fisher's permutation principle, or approximated by the χ^2 with k-1 degrees of freedom.

Exercise: Calculate if there are significant differences between the wines!

Extra-curricular 'fun' activities

AWOL Activity #4: Average internal rank correlation

Quade (1972) proposed a measure of agreement of rankings that averages the rank correlations of the C_2^m pairwise sets of m independent rankings:

$$\rho = E\left[r\left(\boldsymbol{R}_i, \boldsymbol{R}_j\right)\right], \forall i \neq j \ .$$

Under the null hypothesis of no order preference, $\rho = 0$. The estimator is based on a U-statistic:

$$\bar{R} = \frac{1}{C_2^m} \sum_{1 \leq i < j \leq m} \sum r(\boldsymbol{R}_i, \boldsymbol{R}_j)$$

Exercise: Calculate the AIRC using Kendall's tau correlation as the rank correlation measure.

Extra-curricular 'fun' activities

AWOL Activity #5: Fisher's exact test

In The Lady Tasting Tea by David Sandburg, the story of Fisher's exact test is presented. He tells about a lady, Dr. Muriel Bristol, who claimed to be able to tell whether the tea or the milk was added first to a cup of tea. Fisher proposed to give her eight cups, four of each variety, in random order.

Exercise: Calculate the exact distribution under the null hypothesis under two situations:

a. The woman is told there are four of each variety
b. The woman is not told how many there are of each variety

A colleague of Fisher, H. Fairfield Smith, revealed that in the test, the woman got all eight cups correct.

Exercise: Calculate the exact p-value for the woman

In our data collection, we asked several of you to guess the price – are students vs faculty, male vs female, young vs older better in guessing?

Exercise: Calculate the exact p-value for the status, sex, age hypotheses

Results

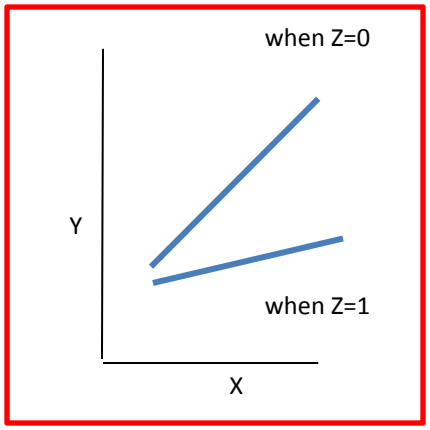
- Students initially see the GRA positions simply as a funding mechanism
  - Many do get valuable experiences
- Students enjoyed the Leadership course
  - More students taking it
- Students are quite reticent to take the Consulting capstone course since it does not teach new statistical methodology
  - They learn being a statistician means not only knowing well the theory and methods ("tool kit") of statistics
  - They learn that as a statistician, they will have to judge the utility of different methods in different settings, and how to use them while interacting effectively with non-statisticians.
  - They learn that how to communicate effectively is not easy!

Concluding remarks

- The training of young statisticians to be 'effective' practicing statisticians involves engaging them in real applied research, and not just providing them a great 'tool kit' of methods and theory
- How to teach young statisticians the art of being a statistician requires engaging them in activity-based approaches, since one learns how to apply statistical methods by doing them, by orally reporting on them, and by writing about them!

Exercise – complications in communicating concepts

1. '**significant p-value**' –
   - Should we mention null & alternative hypotheses?
   - Should we mention if 'effect size' is contextually meaningful or not?
   - Should we mention a real context example?
2. '**interaction**'
   - In words or using a simple graph? (2-dim or more?)
   - Should mention a real context example – i.e. name factors X,Y,Z
3. '**mixed-effects linear model**'
   - Should we mention fixed and random effects?
   - Should we talk about hierarchical sampling or repeated measures longitudinal study designs
   - Should we mention a real context example?



非常感谢

Muito obrigado!