Teaching Statistics in a Community College – Connections

Presenters:
Mary Parker, Austin Community College
Brian Smith, McGill University

In this session, participants will consider introducing new topics into courses they teach. The session will begin with two presentations. Mary Parker will discuss how she includes regression in a freshman math elective course. Brian Smith will discuss how he includes time series analysis into an elementary statistics course. Both will focus on which aspects of the topic they chose to include at that level and why.

Most of the time in this session will be devoted to small groups discussing how they might introduce a particular topic into a particular course. A list of possible topics for discussion will be provided as well as some suggested questions to use in deciding how much detail should be included. In small groups, participants will choose a particular topic and discuss how they would include it as a new topic in a course. If time allows, the group may discuss a second topic as well.

While the main focus of this session is for each participant to consider how they would make choices about which aspects of the topic to include, we will also have available examples from various collections of teaching modules, articles with discussion questions, and other resources that teachers could adapt.

Resources for this session are available from http://www.austincc.edu/mparker/uscots/

We who teach in community colleges spend most of our days working with colleagues who are not also statisticians or statistics teachers. That brings us some special opportunities to enrich our courses and increase the number of students who see statistics as useful in making sense of the world. Some of us are well-connected with the public schools and aware of how the mathematics and science curricula in K-12 include more work on data analysis than in the past. Students and faculty members in college business, science, social science, and vocational classes work with data frequently. How can we use our connections to enhance our statistics courses and to bring more statistics into the other courses we teach? In this breakout session, we'll discuss strategies for choosing topics and the appropriate depth. In small groups, we'll consider and critique some examples of statistics in non-statistics courses. Participants will receive a handout discussing strategies for choosing topics and the depth, some examples, and a list of resources (mostly web resources.)

Robin Lock
Guidelines for Assessment and Instruction in Statistics Education (GAISE) for Undergraduates

The Guidelines for Assessment and Instruction in Statistics Education (GAISE) report on the introductory undergraduate statistics course can be found in its entirety (including appendices with examples) at *http://it.stlawu.edu/~rlock/gaise/*. The six main recommendations and a list of goals for the introductory course are excerpted here.

Members of the GAISE Group: Martha Aliaga, George Cobb, Carolyn Cuff, Joan Garfield (Chair), Rob Gould, Robin Lock, Tom Moore, Allan Rossman, Bob Stephenson, Jessica Utts, Paul Velleman, and Jeff Witmer

Recommendation 1: Emphasize statistical literacy and develop statistical thinking.

We define statistical literacy as understanding the basic language of statistics (e.g., knowing what statistical terms and symbols mean and being able to read statistical graphs), and understanding some fundamental ideas of statistics. Statistical thinking has been defined as the type of thinking that statisticians use when approaching or solving statistical problems. Statistical thinking has been described as understanding the need for data, the importance of data production, the omnipresence of variability, and the quantification and explanation of variability.

Recommendation 2: Use real data.

It is important to use real data in teaching statistics, for reasons of authenticity, for considering issues related to how and why the data were produced or collected, and to relate the analysis to the problem context. Using real data sets of interest to students is also a good way to engage them in thinking about the data and relevant statistical concepts. There are many types of real data including archival data, classroom-generated data, and simulated data. Sometimes hypothetical data sets may be used to illustrate a particular point (e.g., the Anscombe data illustrates how four data sets can have the same correlation but strikingly different scatterplots) or to assess a specific concept. It is important to only use created or realistic data for this specific purpose and not for general data analysis and exploration. An important aspect of dealing with real data is helping students learn to formulate good questions and use data to answer them appropriately based on how the data were produced.

Recommendation 3: Stress conceptual understanding rather than mere knowledge of procedures.

Many introductory courses contain too much material and students end up with a collection of ideas that are understood only at a surface level, are not well integrated and are quickly forgotten. If students don't understand the important concepts, there's little value in knowing a set of procedures. If they do understand the concepts well, then particular procedures will be easy to learn. In the student's mind, procedural steps too often claim attention that an effective teacher could otherwise direct toward concepts.

Recognize that giving more attention to concepts than to procedures may be difficult politically, both with students and client disciplines. However, students with a good conceptual foundation from an introductory course are well-prepared to go on to study additional statistical techniques in a second course such as research methods, regression, experimental design, or statistical methods.

Recommendation 4: Foster active learning in the classroom.

Using active learning methods in class is a valuable way to promote collaborative learning, allowing students to learn from each other. Active learning allows students to discover, construct, and understand important statistical ideas and to model statistical thinking. Activities have an added benefit in that they often engage students in learning and make the learning process fun. Other benefits of active learning methods are the practice students get communicating in the statistical language and learning to work in teams. Activities offer the teacher an informal method of assessing student learning and provide feedback to the instructor on how well students are learning. *It is important that teachers not underestimate the ability of activities to teach the material or overestimate the value of lectures.*

Recommendation 5: Use technology for developing concepts and analyzing data.

Technology has changed the way statisticians work and should change what and how we teach. For example, statistical tables such as a normal probability table are no longer needed to find *p*-values and we can implement computer-intensive methods. We think that technology should be used to analyze data, allowing students to focus on interpretation of results and testing of conditions, rather than on computational mechanics. Technology tools should also be used to help students visualize concepts and develop an understanding of abstract ideas by simulations. Some tools offer both types of uses, while in other cases a statistical software package may be supplemented by web applets. Regardless of the tools used, it is important to view the use of technology not just as a way to compute numbers but as a way to explore conceptual ideas and enhance student learning as well. We caution against using technology merely for the sake of using technology (e.g., entering 100 numbers in a graphing calculator and calculating statistical summaries) or for pseudo-accuracy (carrying out results to multiple decimal places). Not all technology tools will have all desired features. Moreover, new ones appear all the time.

Recommendation 6: Use assessments to improve and evaluate student learning.

Students will value what you assess. Therefore assessments need to be aligned with learning goals. Assessments need to focus on understanding key ideas and not just on skills, procedures, and computed answers. This should be done with formative assessments used during a course (e.g., quizzes and midterm exams and small projects) as well as with summative evaluations (course grades). Useful and timely feedback is essential for assessments to lead to learning. Types of assessment may be more or less practical in different types of courses. However, it is possible, even in large classes, to implement good assessments.

III Goals for Students in an Introductory Course: What it Means to be Statistically Educated

Students should believe and understand why:

- Data beat anecdotes.
- Variability is natural and is also predictable and quantifiable.
- Random *sampling* allows results of surveys and experiments to be extended to the population from which the sample was taken.
- Random *assignment* in comparative experiments allows cause and effect conclusions to be drawn.
- Association is not causation.
- Statistical significance does not necessarily imply practical importance, especially for studies with large sample sizes.
- Finding no statistically significant difference or relationship does not necessarily mean there is no difference or no relationship in the population, especially for studies with small sample sizes.

Students should recognize:

- Common sources of bias in surveys and experiments.
- How to determine the population to which the results of statistical inference can be extended, if any, based on how the data were collected.
- How to determine when a cause and effect inference can be drawn from an association, based on how the data were collected (e.g., the design of the study)
- That words such as "normal", "random" and "correlation" have specific meanings in statistics that may differ from common usage.

Students should understand the parts of the process through which statistics works to answer questions, namely:

- How to obtain or generate data.
- How to graph the data as a first step in analyzing data, and how to know when that's enough to answer the question of interest.
- How to interpret numerical summaries and graphical displays of data - both to answer questions and to check conditions (to use statistical procedures correctly).
- How to make appropriate use of statistical inference.
- How to communicate the results of a statistical analysis.

Students should understand the basic ideas of statistical inference:

- The concept of a sampling distribution and how it applies to making statistical inferences based on samples of data (including the idea of standard error)
- The concept of statistical significance including significance levels and *p*-values.
- The concept of confidence interval, including the interpretation of confidence level and margin of error.

Finally, students should know:

- How to interpret statistical results in context.
- How to critique news stories and journal articles that include statistical information, including identifying what's missing in the presentation and the flaws in the studies or methods used to generate the information.
- When to call for help from a statistician.

"What do you want me to write?"

Improving Students' Verbal Descriptions and Interpretations

Doug Andrews – Professor of Statistics
Dept of Math and Comp Sci, Wittenberg University (in Springfield, Ohio)
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Here are some of the topics that the planned activities are designed to investigate:

- 5 pervasive principles for guiding Exploratory Data Analysis
- 3 key features to note in the distribution of a quantitative variable (and hence to compare in the relationship between a quantitative variable and a categorical variable)
- 3 key features to note in the relationship between two quantitative variables
- characteristics of good and bad confidence interval interpretations
- characteristics of good and bad p-value interpretations and significance test conclusions

Here's a quick summary of the promised pedagogical technique for using peer writing to improve student writing and thinking:

- Describe criteria and standards for responses.
- Solicit and compile student responses.
- Share archived (scored) responses, to norm student scoring.
- Students critique/rate each other's responses.
- Grade students on the quality of their critiques, and/or on the consistency of their ratings with your own ratings.

Here are some of the advantages to using this technique:

- There's low pressure on the (ungraded) initial submissions of interpretations.
- Students see their responses among mixture of good and bad responses.
- Students are forced to reflect on what makes for stronger and weaker responses.
- Afterwards, students are less likely to kid themselves about how much they really understand.
- Establishes expectations for homework responses, exams, project reports, etc.

Assessment
Resource
Tools for
Improving
Statistical
Thinking

Please visit the ARTIST Website at

http://www.gen.umn.edu/artist/

The ARTIST website provides a variety of assessment resources for teaching introductory statistics. We provide assessment items and online tests, resources on student projects, and articles and web links related to assessing student outcomes in introductory statistics courses.

Our goal is to assist statistics instructors in developing and using high quality assessments in their courses, and to provide valid and reliable instruments for research and evaluation studies.

Please see the other side of this flyer for a list of ARTIST resources

ARTIST PROJECT TEAM
Joan Garfield, University of Minnesota
Bob delMas, University of Minnesota
Beth Chance, Cal Poly, San Luis Obispo
Ann Ooms, University of Minnesota

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WHAT YOU WILL FIND AT THE ARTIST WEBSITE

1. Assessment Items and Tests

- **Assessment Builder: a collection of over 1100 items, in a variety of item formats, classified according to statistical topic and type of learning outcome assessed. This database can be used by statistics instructors to generate files in RTF format that can be downloaded and then edited in a word processor.**
- **Online tests for 11 topics (e.g., measures of center, sampling variability) and one overall test of statistical reasoning (CAOS).**
- **Copies of instruments or links to instruments to use in assessing learning outcomes or attitudes for research and evaluation studies.**

2. Alternative Assessments

- **Information, guidelines, and examples of student. projects, article critiques, and writing assignments.**

3. Practical Advice

- **Questions and answers on practical issues related to designing, administering, and evaluating assessments.**

4. References and Links

- **Copies of articles or direct links to articles on assessment in statistics.**
- **Copies of conference papers and presentation on the ARTIST project, and handouts from ARTIST mini-courses and conferences.**

5. Information on Upcoming ARTIST Events

- **Check out our free August workshop in Minneapolis.**

6. Ways to participate as a class tester for ARTIST materials

- **Try out our online tests which provide timely feedback.**

Turn Your Class Into a Research Lab

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Session Outline

1. Overview of three breakout sessions
2. **What is classroom research?** Panelists describe the problems that led them to conduct classroom research. What they learned from their research and how it impacted their teaching of statistics.
3. **Why do classroom research?** To address problems that arise in teaching our courses. What problems do we encounter in teaching statistics that would lead to classroom research studies? (Small group discussion)

In higher education, several terms that include "classroom research", "action research", and "the scholarship of teaching and learning", with separate literatures, have been used to describe research centered on student learning. A model for this type of research is given by delMas, Garfield, and Chance (JSE, 1999) that includes the four steps:

1. **What is the problem?** What is not working in the class? What difficulties are students having learning a particular topic or learning from a particular type of instructional activity? The identification of the problem emerges from experience in the classroom, as the teacher observes students, reviews student work, and reflects on this information. As a clearer understanding of the problem emerges, the teacher may also refer to published research to better understand the problem, to see what has already been learned and what is suggested regarding this situation, and to understand what might be causing the difficulty.

2. **What technique can be used to address the learning problem?** A new instructional technique may be designed and implemented in class, a modification may be made to an existing technique, or alternative materials may be used, to help eliminate the learning problem.

3. **What type of evidence can be gathered to show whether the implementation is effective?** How will the teacher know if the new technique or materials are successful? What type of assessment data will be gathered? How will it be used and evaluated?

4. **What should be done next, based on what was learned?** Once a change has been made, and data have been gathered and used to evaluate the impact of the change, the situation is again appraised. Is there still a problem? Is there a need for further change?

How might the technique or materials be further modified to improve student learning? How should new data be gathered and evaluated?

The session will explore this model, explore examples of classroom-based research and engage in dialogue with teachers on identification of the problems that need investigation by researchers.

Resources related to classroom research, action research, and the Scholarship of Teaching and Learning

delMas, R. C., Garfield, J., and Chance, B. L. (1999), "A Model of Classroom Research in Action: Developing Simulation Activities to Improve Students' Statistical Reasoning" *Journal of Statistics Education* [Online], 7(3) www.amstat.org/publications/jse/secure/v7n3/delmas.cfm

Eisenhart M., and Borko, H., (1993), *Designing Classroom Research: Themes, Issues and Structures*. Allyn and Bacon.

Holland, J. H., Holyoak, K. J., Nisbett, R. E., and Thagard, P. R. (1987), Induction: Processes of Inference, Learning, and Discovery, Cambridge, MA: The MIT Press.

Hollins, E. R. (1999), "Becoming a Reflective Practitioner," in Pathways to Success in School: Culturally Responsive Teaching, eds. E. R. Hollins and E. I. Oliver, Mahwah, NJ: Lawrence Erlbaum Associates.

Hopkins, D. (1993), A Teacher's Guide to Classroom Research, Buckingham: Open University Press.

Hutchings, P., editor, *Opening Lines: Approaches to the Scholarship of Teaching and Learning*, (2000), The Carnegie Foundation for the Advancement of Teaching, Menlo Park, CA.

Hutchings, P., editor, *Ethical Issues in the Scholarship of Teaching and Learning*, (2002), The Carnegie Foundation for the Advancement of Teaching, Menlo Park, CA.

Noffke, S., and Stevenson, R. (eds.) (1995), *Educational Action Research*, NY: Teachers College Press.

Title: Teaching Statistics to Prospective Teachers

Presenters: Phyllis Curtiss and John Gabrosek, Department of Statistics, Grand Valley State University

Summary of Session: Recent reports from national agencies and professional organizations indicate that prospective teachers of mathematics at the K-12 grade levels need to develop a deep understanding mathematics and statistics as unified and coherent disciplines. Unfortunately, many of our undergraduate statistics courses for prospective teachers do a better job of preparing these educators for graduate studies in statistics than they do for teaching in grades K-12.

As part of a multi-year project called "Enhancing the Core," mathematicians, statisticians, and mathematics educators at Grand Valley State University (GVSU) in Allendale, Michigan joined together to enhance the core courses taken by all prospective teachers majoring in mathematics. One of the core courses that is taken by all K-12 prospective mathematics teachers is Probability and Statistics. The course is a calculus-based introduction to probability and statistics.

An important goal of the Enhancing the Core project was to develop teaching materials that build upon the mathematics and statistics content found in the K-12 curriculum. Exemplary K-12 materials were identified, adapted, and extended for use in the college classroom. By using exemplary K-12 curricula as source material, the project helps prospective teachers to gain an appreciation of the connections between the statistics taught to them in the undergraduate course and the statistics they will teach to their K-12 students.

In this breakout session we engage participants in three of the activities. These three activities are described below:

1. Rock, Paper, Scissors for Three – Is It Fair? – Students play the classic Rock, Paper, Scissors game modified for three players. Students are introduced to sample spaces, events, and probability. Special emphasis is placed on designing a "fair game."
2. Dolls and Data (based on an idea from David Coffey, GVSU) – Students are given a collection of action figures and asked to measure the distances from the elbow to the fingertip and from the shoulder to the fingertip. The resulting bivariate data is used to illustrate scatterplots, correlation, regression, and a very special ratio.
3. Coke, It's the Real Thing – or, Is It? – The class designs an experiment to determine whether or not a volunteer can distinguish between Coke and Pepsi. Concepts of hypothesis testing, Type I error, Type II error, p-values, and the binomial distribution are illustrated.

The second page of this summary provides a list of activities developed for the Probability and Statistics course as part of the Enhancing the Core project.

Probability and Statistics – Activity Grid
Investigators: Alverna Champion, Phyllis Curtiss, John Gabrosek
Enhancing the Mathematical Core

Activity Name	Source of Activity	Goals and Content Covered
Are All Samples Created Equal?	Core-Plus, Course 3, Part A, pp.124-127	Students apply the process of taking a simple random sample. Students discover that a simple random sample is more likely to generate a sample representative of the population than a convenience sample.
Uh, Let's Just Call Her Rho	Connected Math, Samples and Populations, Grade 6, pp. 6-18	Students calculate descriptive summaries of quantitative data and investigate the influence of an outlier on these summaries.
The Mighty Thumbtack	Everyday Mathematics, Fifth Grade, Vol. 1, pp. 107-08	Students perform a simple experiment to see that not all outcomes are equally likely. Students see the impact of sampling variability through a comparison of student-to-student results. Class data are used to demonstrate The Law of Large Numbers.
Rock, Paper, Scissors for Three	Investigations in Number, Data, and Space, Between Never and Always, Fifth Grade, pp. 48-55	Students play a modified version of Rock, Paper, Scissors for three. Students design a scoring system to make the game fair.
The Lottery	Developed by Alverna Champion	Students calculate conditional probabilities of various people winning in the short story "The Lottery."
I'm Dieing to Meet Your Expectations	Math Connections, Volume 3a, pp. 263-269	Students develop a strategy for finding the expected score of a discrete random variable. Students find the probability mass function and cumulative distribution function for the discrete random variable.
Making Cents Out of Pennies	Activity-Based Statistics by Richard Schaeffer	Students investigate the distribution of the class means for simple random samples drawn from a known population. Students generate histograms to investigate the Central Limit Theorem and the sampling distribution of the sample mean.
The Blob	Developed by John Gabrosek	Given an irregularly shaped object, students take a random sample and find an interval estimate of the object's area using confidence interval techniques.
Coke, It's the Real Thing–Or, Is It?	Coke or Pepsi, by Marita Levine and Raymond Rowling, Teaching Statistics, Vol. 15, No.1, p. 4-5.	The class designs and conducts an experiment to determine whether or not a volunteer can distinguish between Coke and Pepsi. Students investigate the relationships between Type I error, Type II error, and Power.
Can We Really Trust Those Marstians?	Core Plus, Course 3, part A, p. 157	Students construct confidence intervals for the population proportion. Students use their intervals to investigate the truth of a claim.
Gulliver's Travels	Math Thematics, Book 1, module 6, pp. 396-411	Students collect data on thumb, wrist, and neck size. Students use their data to motivate a discussion of correlation and regression.

Investigations for Introducing Mathematically Inclined Students to Statistics

Allan Rossman and Beth Chance, Cal Poly - San Luis Obispo

Motivation: Key features of the statistics education reform movement include the use of data, activities, and technology to help students understand fundamental concepts and the nature of statistical thinking. Many innovative and effective materials have been developed, but the vast majority have been aimed at "Stat 101," the algebra-based service course. Our goal in this project is to support an introductory course at the post-calculus level around the best features of statistics education reform: data, activities, concepts, and technology. We emphasize issues of data collection and data analysis as well as statistical inference. We ask students to investigate the applications of statistics and also its mathematical underpinnings.

Guiding Principles:

- *Experience the entire statistical process over and over*. From the first chapter we ask students to consider issues of data collection, produce graphical and numerical summaries, consider whether inference procedures apply to the situation, apply inference procedures when appropriate, and communicate their findings in the context of the original research question. This pattern is then repeated over and over as students encounter new situations. We hope that this frequent repetition helps students to appreciate the "big picture" of the statistical process, and to develop their confidence for "doing statistics."
- *Motivate with real studies and genuine data*. Almost all of these investigations center on genuine data from real studies. The contexts come from a variety of scientific disciplines and also from popular media. Some of these studies include classic studies on smoking and lung cancer, as well as recent cases of pulmonary diseases in popcorn manufacturing plants, relationship between night lights and myopia in children, use of shared armrests on airplanes, and lasting effects of sleep deprivation on cognitive ability.
- *Put students in the role of active investigator*. Our materials emphasize active learning and ask students to construct their own knowledge of statistical concepts and methods. They consist primarily of investigations that present a directed series of questions that lead students to explore and apply statistical ideas, often asking them to make conjectures before carrying out the analysis about a statistical concept or a research question.
- *Emphasize connections among study design, inference technique, and scope of conclusion*. Issues of study design come up early and recur throughout our materials. From the opening chapter we lead students to examine when causal conclusions can be drawn, the distinction between randomization and random sampling, and the concept of statistical significance, motivated first through simulation and then through probability models.
- *Use variety of computational tools.* As appropriate, students are asked to use different computational tools, both to analyze data and to explore statistical concepts. Many of the concepts are visualized through interactive java applets and much of the statistical analysis is done with Minitab.
- *Investigate mathematical underpinnings.* We often ask students to use their mathematical training to investigate some of the underpinnings behind statistical procedures (e.g., principles of least squares, effects of transformations).
- *Provide frequent feedback.* Through a series of practice problems and an extensive collection of exercises, students can be asked follow-up questions to immediately test their

understanding of basic terminology and applications, as well as more involved data analyses and mathematical derivations. Instructors can utilize the practice problems between classes to informally assess which topics merit more discussion.

Outline:

	Chapter 1	Chapter 2	Chapter 3	Chapter 4	Chapter 5	Chapter 6
Data Collection	Observation vs. experiment, confounding, randomization		Random sampling, bias, precision, nonsampling errors	Paired data	Independent random samples	Bivariate
Descriptive Statistics	Conditional proportions, segmented bar graphs, odds ratio	Quantitative summaries, transformations, *z*-scores, resistance	Bar graph	Models, Probability plots, trimmed mean		Scatterplots, correlation, simple linear regression
Probability	counting, random variable, expected value	empirical rule	Bermoulli processes, rules for variances, expected value	Normal , Central Limit Theorem		
Sampling/ Randomization Distribution	Randomization distribution of $\hat{p}_1 - \hat{p}_2$	Randomization distribution of $\bar{x}_1 - \bar{x}_2$	Sampling distribution of X, $\hat{p}$	Large sample sampling distributions for $\bar{x}$, $\hat{p}$	Sampling distribution of $\hat{p}_1 - \hat{p}_2$, $\bar{x}_1 - \bar{x}_2$, OR	Chi-square statistic, F statistic, regression coefficients
Model	Hypergeometric		Binomial	Normal, *t*	Normal, *t*, log-normal	Chi-square, *F*, *t*
Statistical Inference	p-value, significance, Fisher's Exact Test	p-value, significance, effect of variability	Binomial tests and intervals, two-sided p-values, type I/II errors	*z*-procedures for proportions *t*-procedures, robustness, bootstrapping	Two-sample *z*- and *t*-procedures, bootstrap, CI for OR	Chi-square for homogeneity, independence, ANOVA, regression

Faculty Development Workshop: As part of the MAA's PREP program, we will offer a professional development workshop on these materials in San Luis Obispo on July 18-22. See www.rossmanchance.com/prep/workshop.html for more information and to apply on-line.
Acknowledgements: We thank the National Science Foundation (DUE/CCLI #9950476, 0321973) for supporting the development of these materials, and Duxbury Press, publishers of *Investigating Statistical Concepts, Applications, and Methods,* by B. Chance and A. Rossman. The preliminary version is available now and the first edition will be available this summer. Additional information and resources are available at: www.rossmanchance.com/iscam/.

Carving the Beautiful Introductory Statistics Course
(What Not to Teach and When Not to Teach It)

Leader: Paul Velleman, Cornell University

Many introductory Statistics courses are weighed down with excess material. First we must carve away these unneeded parts. Then we can begin to show students how to construct a coherent and beautiful model of the topic. We carve away excess stone, but the students build with clay, so we must help them build from the bottom up and from the inside out. By the end of the session we'll have a coherent well-ordered set of topics for the introductory Statistics course.

Note: The nature of the session is to discuss which topics should be in or out of the intro course and what order to teach them in. There is no "right" answer to either of these issues. I plan to present my ideas during the session in a way that will hopefully provoke others to respond with their own thoughts, and which will lead to a spirited discussion.

We will prepare "minutes" of the discussion for later distribution regarding conclusions that we come to as a group.

Concept Mapping in Introduction to Statistics

Marjorie E. Bond, mebond@monm.edu
Monmouth College, Monmouth, IL

References:

Institute for Human and Machine Cognition (IHMC) Cmap Tool Home Page: http://cmap.ihmc.us/Index.html

Joseph Novak's web page: http://www.ihmc.us/users/user.php?UserID=jnovak

Presentation link can be found on http://pavo.coginst.uwf.edu/servlet/SBReadResourceServlet?rid=1064009710027_1483270340_27090&partName=htmltext
Click "information links" under the first concept to watch the presentation.

The idea of Concept Maps was developed in 1970's by Joseph Novak. It is based on theory of knowledge and theory of learning.

Theory of knowledge

- All knowledge is built up from Concepts and Propositions
- Concepts combine to build proposition
- Concepts – A perceived regularity in events or objects, or records of events or objects, designated by a label. words or symbols

- Propositions: Two or more concepts combined to form a statement about something: a unit of meaning. Relationship of concepts.

Theory of Learning

- Concept maps is a tool to represent the structure of knowledge
- concept maps are context dependent
- Concepts maps are based on the idea that storage of knowledge is not a linear string

Concepts Maps are only one way to represent knowledge. Other ways can be simple flowcharts, maps, etc.

New epistemological thinking

Toward:

- constructivist epistemology which holds that knowledge is a human construction and evolves over time.

- Each person must construct their own knowledge in their head. You can't give it.

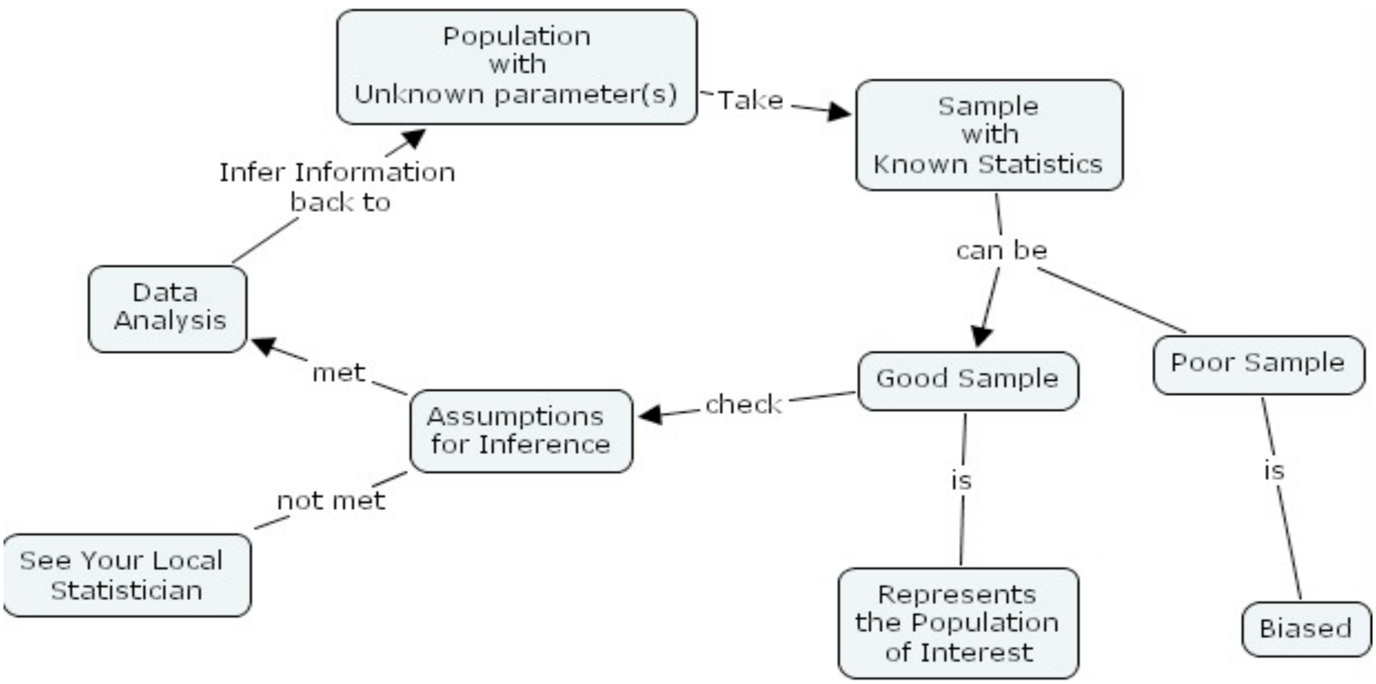
Away from:

- Positivist epistemology holds that knowledge derives from empirical observation and is "unfettered" by varying human ideas over time.

- Knowledge is discovered. It will last forever.

Key idea: Each person must construct her/his own meanings for concepts and propositions from experiences over time, building her/his knowledge structure.

An Example, dealing with Data Analysis (3rd Concept Map of this handout.) THERE CAN BE MORE THAN ONE CONCEPT MAP for this information. This map was useful to this student.



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Long download using a modem

Readiness Assessment Tests (RATs)

Leaders: William Harkness and Laura Simon, Penn State University

Have you found yourself wishing that students actually completed your reading assignments before coming to class (or at all)? Do you find yourself wishing you had more class time to work with students on interesting problems rather than using valuable class time teaching basic concepts? If your answer to either of these questions was "yes," then you might want to consider implementing Readiness Assessment Tests (RATs) in your classes.

Attendees of this breakout session will be introduced to the Readiness Assessment Test method that has been used successfully by introductory statistics courses at Penn State University over the past five years. Attendees will learn about RATs, and come to appreciate their value, by actually working through the process in the same way students in their classes would. The method involves four key-steps: 1) students first take an individual Readiness Assessment Test 2) then students take the same Readiness Assessment Test as a group, 3) students are given an opportunity to appeal their group results, and finally 4) students complete group activities that allow them to immediately apply their newfound knowledge. Attendees will not only be introduced to the method used in several disciplines across Penn State, but will also be given the opportunity to discuss their concerns about, and to formulate viable solutions for, implementing RATs in their own classes.

Note: Much of the information needed for this session will be given out during the session; in an effort not to "give away" the essence of the activities and discussion, that information is not included here. A separate handout will be prepared and will be available during and after their session, for you to include in your resource notebook.

Research Breakout Session #2
Research in Statistics Education: It's Not a Solo Sport

The goals of this session are (1) to increase participants' awareness of the value of (and frequency of) collaborations in conducting statistics education research, (2) to convey -- through personal descriptions -- several different models of collaboration (who is involved, how they work together, some benefits derived from the collaboration, and some obstacles that were overcome, etc.), and (3) to give the participants a chance to network and begin to find people with common interests who might be potential collaborators. To achieve these objectives and to keep the session interactive and contextualized, the format will include a short icebreaker to get people thinking about their own collaboration experiences and research interests, followed by a panel of 4 people representing different collaborations in statistics education research who will share their experiences, time for audience discussion with the panelists, and a meet-n-greet activity at the end to help people initiate potential research collaborations.

Research groups represented by session panelists

Institution: Carnegie Mellon University

Research Group Members: Marsha Lovett (panelist), Oded Meyer, Joel Greenhouse, Brian Junker, Rob Kass, Ken Koedinger

Description: StatTutor is an intelligent tutoring system developed at Carnegie Mellon that facilitates understanding of statistical ideas and analytical techniques by helping students construct useful knowledge representations and thereby develop effective problem-solving skills. It uses a specified outline of steps to follow in solving problems, or "scaffolding". StatTutor uses scaffolding and immediate feedback flexibly, tracking and responding to individual students as they navigate the learning environment.

Related Web Pages:
http://www.cmu.edu/stattutor/people.html
http://www.psy.cmu.edu/LAPS/
http://www.causeweb.org/research/projects/carnegiemellon.php

Institution: University of Massachusetts, Amherst

Research Group Members: Cliff Konold (panelist), Alexander Pollatsek, Arnie Well

Description: Our research initially focused on how adults reason about statistics and probability before receiving any formal instruction, and we used mosly indepth clinical interviews in these studies. More recently, we have been focusing on younger students learning data analysis and how their understanding develops over instruction. We have been using various methods to study these, including group interviews and analysis of classroom interactions and student artifacts.

Related Web Pages:
http://www.umass.edu/srri/serg/index.html
http://www.umass.edu/srri/serg/projects.html
http://www.causeweb.org/research/projects/umass.php

Institution: University of Minnesota and California Polytechnic State University

Research Group Members: Joan Garfield (U of MN), Bob delMas (panelist, U of MN), Beth Chance (Cal Poly)

Description: Our research has focused on the use of simulation software to develop ideas related to statistical inference (e.g., sampling, sampling distributions, and confidence intervals), and ways to teach these concepts using the software. We are also interested in developing assessment tools and techniques to reveal students' statistical literacy, reasoning and thinking. We engage in collaborative classroom research, using students in our introductory statistics classes in our research studies.

Related Web Pages:
http://www.gen.umn.edu/research/stat_tools/
http://www.gen.umn.edu/artist/
http://www.causeweb.org/research/projects/minnesota.php

Institution: Central Michigan University, USA and Cyprus Ministry of Education, Nicosia, Cyprus

Research Group Members: Carl Lee (panelist, Central Michigan University)
Maria Meletiou-Mavrotheris (Cyprus Ministry of Education)

Description: Our research has focused on the progression of learning statistical concepts in an introductory statistics course using classroom-based research methodology. We are particularly interested in how students learn the concepts of variation, distributions and the difficulty occurs in the process of learning these concepts. More recently, we began a research study to investigate the retention of statistical concepts three months after completing their course work using problem posing research methodology.

Related Web Pages:
http://www.cst.cmich.edu/users/lee1c/carllee/
http://www.stat.auckland.ac.nz/~iase/serj/SERJ1(2).pdf

"Guidelines for Teaching and Learning Statistics within the PreK-12 Mathematics Curriculum"

Christine Franklin, University of Georgia
Gary Kader, Appalachian State University.

Introduction

In this breakout session ideas and activities from the document, *A Curriculum Framework for Pre K-12 Statistics Education,* will be presented. *The Framework* was developed though ASA funding of a Strategic Initiative Grant (GAISE) proposed by the Advisory Committee on Teacher Enhancement in March 2003. The main objectives of this document are to provide a conceptual framework for Pre K-12 statistics education and to provide guidelines toward developing statistically literate citizens. *The Framework* was endorsed by ASA in early May 2005.

The foundation for the *Framework* rests on the National Council of Teachers of Mathematics' (NCTM) *Principles and Standards for School Mathematics* (2000). The NCTM *Standards* are the basis for most of the state curriculum guidelines in place for Pre K-12 education. The newly written *Framework* is intended to support and complement the objectives of the NCTM *Principles and Standards,* most notably the *Data Analysis and Probability Strand.*

The Framework provides a conceptual and developmental structure for statistics education that presents a coherent model for the overall statistics curriculum at the Pre K-12 level. *The Framework* is designed to provide stakeholders such as writers of state standards, writers of assessment items, educators at teacher preparation programs, curriculum directors, and Pre K-12 teachers with guidance in developing standards in statistics and data analysis as part of the Pre K-12 mathematics curriculum.

This breakout session will provide a general overview of the *Framework* with illustrations of several activities.

The Framework

The Framework presents statistical problem solving as an investigative process that involves four components:

(1) Question formulation, (2) Data collection, (3) Data analysis, (2) Interpretation.

An *understanding of variability* is crucial for the practice of this process. Understanding the role of variability in the statistical problem solving process requires maturation in statistical thinking. The beginning student cannot be expected to make all of these linkages. Statistical education should be viewed as a developmental process, and this *Framework* provides guidelines for statistical education over the three developmental levels, A, B, and C. These three levels roughly parallel the Pre K-5, 6-8, and 9-12 grade bands of the NCTM *Standards*. Although we hope that the school curriculum is such that these three levels are somewhat equivalent to elementary, middle, and secondary, *The Framework* levels are based on experience not age. Thus, a middle school student who has had no prior experience (or no rich experiences) with statistics will need to begin with Level A concepts before moving to Level B. This holds true for a secondary student as well - if a student hasn't had Level A and B experiences prior to high school, then it is not appropriate to jump into Level C expectations. At Level A the learning is more teacher driven, but transitions toward student-centered work at Level B and becomes highly student driven at Level C. Hands-on, active learning is a predominant feature throughout.

The Framework presents a conceptual structure for statistics education in a two-dimensional model. One dimension is defined by the components of the statistical problem-solving process along with the nature of and the focus on variability. The second dimension is comprised of the three developmental levels.

Two Examples from *The Framework*

Example 1 – What type of music do students like?
Suppose students are interested in knowing what type of music (rock, country, or rap) is most popular among their peers in school? Level A students could collect data in their classroom and analyze the data by summarizing frequencies for the different categories in a table or bar graph. They could draw conclusions about the most popular type of music and the least popular in their classroom. At Level B, students could transition to summarizing categorical data by reporting relative frequencies – making the leap to proportional reasoning for comparing categories or groups. Additionally, data on different types of music "liked" or "not liked" might be summarized in a two-way frequency and possible associations explored through conditional relative frequencies. Regarding the musical preference question, level C students will transition to understanding the notion of estimating the population proportion who prefer a particular type of music with the sample proportion, exploring the sampling distribution (through simulation) of the sample proportion, and developing the idea of the "margin of error" associated with the sample proportion.

Example 2 – Developing the Concept of a Mean
At the inaugural *TEAMS* conference, sponsored by the ASA, in October 2003, then President of NCTM, Johnny Lott, gave one of the keynote addresses. In his address, he asked statisticians to help him see how the understanding of the mean advances from elementary grades to middle grades to high school grades within the framework of the NCTM Standards. Clearly defining the expected development of a concept at each level, as illustrated in the previous example, is a major goal of this document and one that nicely complements the NCTM standards. Another example of clarity of concepts at each level relates to the notion of the mean for a collection of numerical data. In *The Framework,* we attempt to clarify this distinction as follows:

Level A: The notion that the mean is the "fair share value"
Level B: The notion that the mean is the "balancing point" of a distribution
Level C: The notion that the sample mean is an estimate of the population mean, as well as understanding the concepts of the sampling distribution of the sample mean (through simulation) and the margin of error associated with the sample mean.

Summary

A good deal of progress has been made in statistics education in recent years, but there is still plenty of room for improvement. State standards and assessments are all over the map and the data analysis portions are often poorly structured. Textbooks and other teaching materials tend to be unfocused with many errors (unless these materials have statistics educators as part of the writing team). The Pre K-12 guidelines in *The Framework* have already made a positive impact in the state of Georgia with the current revisions of the Georgia state mathematical standards. It is the hope that *The Framework* will provide a conceptual foundation in data analysis for the interested stakeholders.

The Framework also serves as an essential background for moving more students toward a major or minor in statistics at the undergraduate college level. Most importantly, it is the goal of this *Framework* to help educators work toward the important goal of developing statistically literate citizens who can use statistics to make reasoned judgments, evaluate quantitative information, and value the role of statistics in everyday life. The complete report can be viewed at http://it.stlawu.edu/~rlock/gaise/

It's all about them

Using student-centered data and student data projects to motivate learning of Statistics

Robert Gould, UCLA

Abstract: Teaching and learning statistics can be greatly improved by using real data. There are many sources of real data, but whether your students will consider it real is another matter. One approach is to encourage students to use data from their every day lives. These data can be used to collect an on-the-cuff data set for an in-class demonstration, or can be part of a longer "project" assignment. Participants will learn by doing, which means they will collect data about themselves and engage (on a time compressed scale) in the same sorts of discussions we would hope their students will engage in. An important component will be to discuss ways of making the data collection non-embarrasing and non-threatening.

At the 2004 *Beyond the Formula*, Bryce, Hoerl, and Snee issued a challenge to provide students with datasets that are not just interesting, but also useful. And useful to the students themselves. In this spirit, I issue the same challenge to the breakout session to discuss and develop ways in which we can bring statistics directly into students lives.

As an example of one such method my colleague Mahtash Esfandiari worked out, we'll talk about using "self help" questionnaires in class. These questionnaires serve as the sugar that helps the statistical medicine go down. While students gain insight into how they handle various aspects of their social and academic life (e.g. conflict resolution), they also learn psychometric theory (the theory of test development) and data analysis. These quizzes (lets call them by the more formal "self-assessment instruments") provide rich ground for discussing a variety of topics covered in introductory and advanced statistics courses.

To illustrate, we'll evaluate ourselves on one such assessment item, the "USCOTS Teachers Self-Assessment Inventory." This evaluation may or may not lead to greater insight into how you approach the teaching of statistics. But in any event, it will lead us to discussion of some statistical topics, and we'll discuss ways of using the test to teach those topics to students.

Handouts will include the syllabus from Prof. Esfandiari's class that was based solely around a similar such exercise, but focused more on inter-personal relationships. The Conflict Resolution Questionnaire she used will be included.

References

1. Bryce, Hoerl, Snee, "Statistical Thinking Workshop: The Theory Behind a Statistical Thinking Approach", Beyond the Formula VIII, August 2004.
2. Gal, Iddo & Ginsburg, Linda, "The Role of Beliefs and Attitudes in Learning Statistics: Towards an Assessment Framework", Journal of Statistics Education, v.2, n.2 (1994).
3. Gould, Stephen Jay The Mismeasure of Man, WW Norton and Company, New York, 1981.
4. Roberts, Seth, "Surprises from Self-Experimentation: Sleep, Mood, and Weight", Chance Magazine, vol. 14, No.2, 2001.

Using Self-assessment inventories to provoke classroom discussions

Self-assessment inventories typically consist of a series of statements to which we are invited to respond with an integer from 1 to 5 in order to indicate how strongly we agree or disagree with the statement. The data themselves provide students with a chance to work with ordered, categorical variables in a way that is fairly realistic, and also quite likely one of the most common instances of categorical variables in the research literature.

In our breakout session we will examine an inventory designed to help you assess your approach to teaching statistics. We modified this slightly so that it could be given to your students and used for them to assess how they learn statistics. This items are not meant to suggest a right or wrong approach and, indeed, may be substantially flawed! They are meant to identify certain characteristics the students might not have known about, and, more importantly, to provoke discussion about how such inventories are constructed and other statistical issues.

Usually, the statements (called items) in an inventory are organized into clusters, and each cluster is meant to measure a different aspect of a person. This aspect is called a construct. For example, in our student self-assessment inventory, one construct claims to measure "your perception of the role of the student in learning statistics." This cluster consists of 5 items, and students are asked to add their responses to these 5 items and report the total. When they are done with the quesionnaire, they will have, in addition to 15 responses to the individual items, 3 totals for each of the three clusters, and one "grand" total.

These scores can be used to help with ideas about distributions. What distribution do they think they will see for item #1 or item #2? How will this compare to the distribution for cluster #1? To the grand total? Which distribution should be the most symmetric, and why? (This can lead or follow a discussion of the Central Limit Theorem, and, more importantly, to the assumptions behind the CLT. Do these assumptions apply here? Students should be encouraged to make predictions about what shapes they expect to see, and then check them by making pictures of the distributions with the available data.)

Students, and humans, are naturally eager to compare themselves to others. Unlike, say, height, where we have a clear understanding of what it means to be 3 inches shorter than someone else, it is not clear what it means to be 3 points below someone else on construct #2, for example. And it is not clear how we should compare scores on construct #2, say, with construct #3. This leads to a discussion of z-scores, and students can construct their own z-scores for the cluster scores and the grand total, and compare their standing to others in the class.

Finally, with more advanced students, these can lead to rather serious and "deep" discussions about the validity of these constructs. (This has been a matter of debate for at least a century, now.) One the one level, they can argue about whether the constructs even "exist", and whether or not they are useful. On another level, they can discuss whether the items are actually measuring the construct they claim to measure. They can then discuss means for verifying this with data, or with further experiment. Stephen Jay Gould's book The Mismeasure of Man provides a historical and cultural overview of the abuse of such questionnaires, and the exposure this questionnaire provides might help students understand some of the thornier points Gould raises.

Students beyond the introductory level can learn about measuring associations with non-continuous variables, and what these associations might mean in terms of the validity of the items and the constructs. They could also learn how "correspondance analysis" might help them detect "types" of people based on their pattern of responses.

Self-measurement, whether through a questionnaire or less formal means, is an increasing part of our internet-based, web culture. We hope this breakout serves as one step in helping us discover ways for statistics to help students learn about themselves and for knowledge of oneself to help one learn statistics.

Dennis Pearl

Connecting your Teachers to your Courses: What Can We Learn from Statistics Departments who Have Statistics Teacher Training Programs?

The American Statistician
"Preparing Graduate Students to Teach Statistics", February 2005, pages 1-18.

Introduction article by David Moore

- How do we teach? Good evidence that "active learning" strategies are superior to the "information transfer" model.
- Effective teaching strategies place a greater burden on the instructor.
- Whom are we training? Have to be sensitive to the diversity of the population of graduate students.
- What should we do?
    - "Don't shield your eyes, plagiarize."
    - Training programs should model good instructional practices.
    - Need to have regular monitoring and mentoring of instructors.

Model programs

"A Course in Teaching Statistics at the University Level" at Columbia University

- Combines practice in statistics demonstrations and drills, discussion of teaching strategies and feedback on classroom teaching.
- A memorable first day of the teaching-statistics class.
- Practical advice and review of research findings on teaching methods.
- Students eventually prepare demonstrations or drills to share.
- Group discussion on good and bad teaching styles, ways to encourage student involvement, testing and grading, etc.

"Training Statistics Teachers at Iowa State University"

- Beginning assignment of a graduate student is as a laboratory assistant or grader.
- Assist in activities in the laboratory setting.
- Later the students will become instructors of their own courses. Department has many resources to help them including a teaching manual, homework assignments and answer keys, files of old exams, and outlines of lecture notes.
- Weekly meetings for all course instructors, discussing common difficulties.
- Instructors are evaluated both by class visits and private meetings.

"Training Graduate Students at Penn State University in Teaching Statistics"

- Description of Stat 200 consisting of computer labs and large group meetings (LGMs).
- Students are given greater responsibility for learning including weekly reading and homework assignments, readiness assessment quizzes, and work in computer labs. (TAs are not used in teaching Stat 200.)
- All new TAs take a course "Communicating Basic Statistical Concepts". This helps to assess the TAs' knowledge of statistical concepts, give them practice on some of their TA duties, and give them some oral communication experience.
- TAs serve primarily as lab or course assistants.

"TA Training at Virginia Tech: A Stepwise Progression"

- Expose TAs to sound teaching principles through their own graduate coursework
- Training in and practice in statistical consulting.
- Graduated system of teacher training:
  - Paper grading
  - Teaching a recitation section of introductory statistics
  - Teach an introductory class with full responsibility
- Course coordinator aids instruction by sets of notes. Blackboard used in class management.
- Mid-semester and end-of-semester student evaluations.
- Hope for a teaching director to be in charge of mentoring TAs and coordinating training.