ASA Strategic Initiative GAISE

Guidelines for Assessment and Instruction in Statistics Education

College Report

Special thanks to
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Slides with yellow text are courtesy of Robin Lock

Outline of This Talk

- Overview of GAISE project
  - Funded by American Statistical Association
  - College Project
  - K-12 Project (will not discuss this one)
- GAISE recommendations on *how* to teach the introductory course
- Recommendations on *what* should be included

GAISE College Group

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The Goal

Produce a set of recommendations and guidelines for instruction and assessment in introductory statistics courses at the undergraduate level.

The Many Flavors of Introductory Statistics

Consumer ⟷ Producer

Discipline-specific ⟷ General

Large lecture ⟷ Small class

Year ⟷ Semester ⟷ Quarter ⟷ Block

H.S. (AP) ⟷ Two year college ⟷ Four year college ⟷ University

Challenge in Writing Guidelines

Give sufficient structure to provide real guidance to instructors.	Allow sufficient generality to include good practices in the many flavors.

Four Part Report

- Introduction and History
- Goals for Students in an Introductory Course: *What it Means to be Statistically Educated*
- Six *Recommendations* for helping teachers achieve those goals
- Appendix of *Examples and Suggestions*

ASA Endorsement

By Unanimous vote on May 17, 2005

The ASA Board of Directors appreciates and supports the efforts of the undergraduate statistics writing group and endorses the six GAISE recommendations for introductory college statistics courses as an aid to enhancing statistics education at the undergraduate level.

Six Recommendations

1. Emphasize statistical literacy and develop statistical thinking
2. Use real data
3. Stress conceptual understanding rather than mere knowledge of procedures
4. Foster active learning in the classroom
5. Use technology for developing conceptual understanding and analyzing data
6. Integrate assessments that are aligned with course goals to improve as well as evaluate student learning.

Recommendation #1

Emphasize statistical literacy and develop statistical thinking.

•Statistical literacy: understanding the language and ideas of statistics

•Statistical thinking: the thought process statisticians use to answer a scientific question with data

Suggestions for Teachers

- Model statistical thinking for students, working examples and explaining the questions and processes involved in solving statistical problems from conception to conclusion.
- Show students how to use technology effectively to manage data, explore data, perform inference, and check conditions that underlie inference procedures.
- Give students practice developing and using statistical thinking. This should include open-ended problems and projects.
- Give students plenty of practice with choosing appropriate questions and techniques, rather than telling them which technique to use and merely having them implement it.
- Assess and give feedback on students' statistical thinking.

Recommendation #2

Use Real Data.

Sources for real data include:

•Textbooks

•Websites such as

- **•"Dazzle" – data and storage library: lib.stat.cmu.edu/DASL/**
- **•Journal of Statistics Education data archive: www.amstat.org/publications/jse/jse_data_archive.html**
- **•www.pollingreport.com (recent polls on numerous topics)**

Suggestions for Teachers

- Search for and use *summaries* based on real data
- Use data to *answer questions* relevant to the context, and to generate new questions.
- Make sure questions used with data sets are *of interest to students* – if no one cares about the questions, it's not a good data set for the introductory class.

More Suggestions for Teachers

- Use class-generated data to formulate statistical questions and plan uses for the data before developing the questionnaire and collecting the data. (Example: ask questions likely to produce different shaped histograms, use interesting categorical variables to investigate relationships.) It is important that students' privacy is maintained.
- Get students to practice entering raw data using a small data set or a subset of data, rather than spending time entering a large data set. Make larger data sets available electronically.
- Use subsets of variables in different parts of the course, but integrate the same data sets throughout. (Example: do side-by-side boxplots to compare two groups, then later do two-sample *t*-tests on the same data. Use histograms to investigate shape, then later to verify conditions for hypothesis tests.)

Recommendation #3

Stress conceptual understanding rather than mere knowledge of procedures.

- Most introductory courses contain too much material.
- 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

Suggestions for Teachers

- View the primary goal as not to cover methods, but to discover concepts.
- Focus on students' understanding of key concepts, illustrated by a few techniques, rather than covering a multitude of techniques with minimal focus on underlying ideas.
- Pare down content to focus on core ideas in more depth.
- Use technology for routine computations, use formulas that enhance understanding.

An Example of Using Formulas for Conceptual Understanding rather than for Computation:

Recommendation #4

Foster active learning in the classroom.

Types of active learning include:

- Group or individual problem solving, activities and discussion.
- Lab activities (physical and computer-based).
- Demonstrations based on data generated on the spot from the students.

Suggestions for Teachers

- Ground activities in the context of real problems.
- Intermix lectures with activities, discussions, labs.
- Precede computer simulations with physical explorations.
- Collect data from students.
- Encourage predictions from students about the results of a study before analyzing data.
- Do not use activities that lead students step by step through a list of procedures, but allow students to discuss and think about the data and the problem.
- Plan sufficient time to introduce, conduct and wrap up the activity all in the same class.
- Provide lots of feedback and assessment.

Recommendation #5

Use technology for developing conceptual understanding* and *analyzing data.

- Graphing calculators
- Statistical packages
- Educational software
- Applets
- Spreadsheets
- Web-based resources including data sources, on-line texts, and data analysis routine
- Classroom response systems.

Suggestions for teachers on ways to use technology:

- Access large real data sets
- Automate calculations
- Generate and modify appropriate statistical graphics
- Perform simulations to illustrate abstract concepts
- Explore "what happens if…"- type questions
- Create reports

Things for teachers to consider when selecting technology tools:

- Ease of data entry, ability to import data in multiple formats
- Interactive capabilities
- Dynamic linking between data, graphical, and numerical analyses
- Ease of use for particular audiences
- Availability to students
- Portability

Recommendation #6

Integrate assessments that are aligned with course goals to improve as well as evaluate student learning.

- Students will value what you assess.
- Assessments need to focus on understanding key ideas and not just on skills, procedures, and computations.
- Useful and timely feedback is essential for assessments to lead to learning.
- Various 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.

Types of Assessment

- Homework
- Quizzes and exams
- Projects
- Activities
- Oral Presentations
- Written reports
- Minute papers
- Article critiques

Suggestions for Teachers

- Integrate assessment as an essential (and current) component of the course.
- Use a variety of assessment methods.
- Assess statistical literacy using assessments such as interpreting or critiquing articles in the news and graphs in media.
- Assess statistical thinking using assessments such as student projects and open-ended investigative tasks.
- For large classes
  - Use group projects instead of individual projects
  - Use peer review
  - Use multiple choice questions that focus on choosing interpretations (e.g. of graphs and studies) or selecting appropriate statistical procedures.

Recommendations for Making It Happen

Start with small steps, for example:

•Add an activity to your course
•Have your students do a small project
•Integrate an applet into a lecture
•Demonstrate the use of software to your students
•Increase the use of real data sets
•Add a case study (newspaper story <-> journal article)
•Choose one topic to delete from the list you currently try to cover and using the time saved to focus more on understanding concepts.

Recommendations on What Should be Taught

GAISE Section titled *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 (in order 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.

Some Resources

GAISE Reports:
http://www.amstat.org/education/gaise

American Statistician paper on concepts:
http://anson.ucdavis.edu/~utts/AmerStat2003.pdf

Good Resources for Statistics Teachers:
http://anson.ucdavis.edu/~utts/statlinks.html