The ASA GAISE Project:

Guidelines for Assessment and Instruction in Statistics Education

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What Should Students Learn?

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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.

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*

GAISE Report
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.

Why Change the “Traditional” Course?

The Situation:

Introductory Statistics has been taught almost the same way for 30 years.

The Consequence:

Most students don’t learn what they need to know in modern society

Much Has Changed in 30 Years!

The Audience

- Broader set of majors represented, many will never "do" statistics
- Greater age mix – more likely to have "returning" students
- More students who have already learned some statistics before college (e.g., huge growth in Advanced Placement Statistics in US)

The Tools For Students

- Universal use of calculators, most have keys for mean, standard deviation, etc.
- Universal access to computers
- Programs like *Excel* have standard statistical features
- Programs like *Minitab* and *SPSS* are now menu-driven

The World Around Us

- Many more studies reported in the news
- Abundance of examples available on the Internet through sites like Gallup, USA Today, Bureau of Labor Statistics, CNN, etc.
- Journal articles available on-line

Consequences of These Changes

- Need to understand *how* studies are conducted
- Need to be able to *interpret* results
- Need to recognize *common mistakes* made in the media
- Less need for hands-on computation

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What Should Students Learn?

- Two Sources:
  - *GAISE* Report:
    - Goals for Students in an Introductory Course: What it Means to be Statistically Educated
  - Utts, Jessica (2003), What educated citizens should know about statistics and probability, *The American Statistician*, 57(2), 74-79

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

Source: GAISE Report

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.

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Students should believe and understand why:

- 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 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 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.
- How to make appropriate use of statistical inference.
- How to communicate the results of a statistical analysis.

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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.
- 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.

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Seven Important Topics (with examples)

Source: Utts, Jessica (2003), What educated citizens should know about statistics and probability, *The American Statistician, 57(2), 74-79*

1. Cause and effect
2. Significance versus importance
3. “No effect” versus low power
4. Biases in surveys/questions
5. Probable coincidences
6. “Confusion of the inverse”
7. Average versus normal

Cause and Effect

The Problem:

Concluding that an explanatory variable *causes* a change in a response variable, based on an observational study.

Example 1 (from *USA Today* newspaper):

"Attending religious services [explanatory variable] *lowers* blood pressure [response variable] more than tuning into religious TV or radio, a new study says..."

Cause and Effect, continued

Example 2:

“[The observed relationship between arteriosclerosis (explanatory variable) and Alzheimer's (response variable)] has implications for prevention, which is good news. If we can prevent arteriosclerosis, we can prevent memory loss over time, and we know how to do that with behavior changes...”

The Solution:

Teach the difference between:

- Randomized experiments (can conclude causation)
- Observational studies (cannot conclude causation)

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Statistical Significance vs Practical Importance

The Problem:

A statistically significant finding may not have much practical importance, especially with large samples.

Example:

"Spring birthday conveys height advantage" (*Reuters* article, reporting study in *Nature*)

Heights of 507,125 military recruits, found highly significant different in heights for recruits born in spring and fall. Difference in means = 0.6 centimeters, or about 1/4".

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Significance vs Importance, continued

The Solution:

- Explain carefully what a *p-value* really means
- Emphasis confidence intervals for finding the *magnitude* of an effect
- Whenever possible, discuss the magnitude of an effect or relationship after doing hypothesis testing examples

Low Power versus No Effect

The Problem:

In small studies only a medium to large effect will be statistically significant, yet lack of statistical significance is often interpreted as a finding of *no effect* or *no relationship*.

Example:

"For [women 40-49] it is clear that in the first 5-7 years after study entry, there is no reduction in mortality from breast cancer that can be attributed to screening..."

Low Power vs No Effect, continued

Example, continued:

In fact the relative risk after 7 years of follow-up was 1.08, with 95% confidence interval of 0.85 to 1.39

So, in fact it is unknown if there is an effect, and the *conclusion* of "no reduction in mortality" is dangerously misleading.

The solution:

Make sure students understand that it is not appropriate to *accept* a null hypothesis, and that sample size is a big factor in determining the *p-value.*

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Confusion of the Inverse

The Problem:

Confusing a conditional probability P(A|B) with the conditional probability P(B|A)

Example:

A = Test positive for a disease

B = Actually have the disease

P(A|B) = Probability of positive test if have disease

Most likely very high.

P(B|A) = Probability of having disease, if test is positive

For rare diseases, most likely low

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Confusion of the Inverse, continued

The Problem:

Confusing a conditional probability $P(A|B)$ with the conditional probability $P(B|A)$

The Solution:

Show students some examples of this, with tree diagrams or "hypothetical 100,000 table." (See *Mind On Statistics*, Utts/Heckard.) They can understand this idea if they see examples with numbers.

SUMMARY

- Teach material of relevance to students' lives, not the old-fashioned "how to"
- Use lots of examples - students remember them
- Create your own list of important ideas

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Internet Resources

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

ARTIST- Assessment Resources:
    https://app.gen.umn.edu/artist/

CAUSEWeb:
    http://www.causeweb.org

34 Websites with Resources for Statistics Teachers:
    http://anson.ucdavis.edu/~utts/statlinks.html