Using research papers as a tool in teaching introductory statistics

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Abstract

The introductory course in statistics has traditionally been taught as a collection of computationally intensive activities. In recent years, many statisticians have become involved in the reform movement in statistical education aimed at the teaching of introductory statistics. Those interested in reform want to emphasize statistical thinking and understanding and help students appreciate the role of statistics in the scientific process and in life. This paper suggests using research papers from refereed journals to illustrate how different statistical concepts are used together in scientific inquiry. In addition, it is hoped that students will see the value and relevance of statistics in their own lives and careers through examining research in their own areas of interest.

Keywords: Introductory statistics, research paper.

1. Introduction

Most instructors teaching introductory statistics classes today were trained in the traditional method. They attended lectures on the mechanics of statistical methods and the theory of probability and mathematical statistics and their involvement in the course was generally limited to working the assigned problems. Since this is how they learned, it seemed natural to teach their students in the same manner, focusing on computational skills and compartmentalized knowledge. This approach has failed dismally. The introductory statistics course is regarded by most students as difficult, unpleasant, and totally irrelevant to their field of study. According to Butler (1998, p. 84) “although increasing numbers of
adults are completing introductory level statistics courses, the adults do not often use statistics in their jobs and when they do try, the results are a shambles”. This dissatisfaction with the introductory course has, over the past twenty years, led to considerable interest in creating a new model for this course.

2. The reform movement

In recent years, many statisticians have become involved in the reform movement in statistics education. As a part of the Curriculum Action Project of the Mathematics Association of America (MAA), George Cobb coordinated a focus group on Statistics Education. The report was published in the MAA volume *Heeding the Call for Change* (Cobb (1992)). It included the following recommendations:

- Emphasize statistical thinking.
- More data and concepts, less theory and fewer recipes.
- Foster active learning.

The National Science Foundation funded several projects to implement aspects of the reform (Cobb (1993)).

The American Statistical Association (ASA) also provided support for statistics education by funding the Guidelines for Assessment and Instruction in Statistics Education (GAISE) Project. This project consisted of two groups, one focused on K-12 education and the other on the introductory college course. In 2004, the college group presented their report, which built on the previous recommendations of the Cobb report. Their recommendations are:

- Emphasize statistical literacy and develop statistical thinking.
- Use real data.
- Stress conceptual understanding rather than mere knowledge of procedures.
- Foster active learning in the classroom.
- Use technology for developing conceptual understanding and analyzing data.
- Use assessments to improve and evaluate student learning (Aliaga et al. (2004)).
3. Examining student outcomes

By implementing the recommendations from the GAISE report, it is hoped that students will not only acquire some amount of statistical literacy, but also learn the basic elements of statistical thinking. In assessing the effectiveness of a statistics class Garfield suggested the desired outcomes of an introductory course should include:

- **Learning** — students’ understanding, reasoning, thinking.
- **Persistence** — leading students to use their statistical knowledge and skills after they leave the course.
- **Attitudes and beliefs** — about the value and importance of statistics and about themselves as learners and users of statistics. (Garfield et al. (2002), p. 3)

While the most commonly discussed outcome is learning, it is important to consider the other two categories as well. Statistics instructors need to encourage positive attitudes and help students see the value of statistics in order to increase their chances of using statistics in their personal lives and their professions.

4. Using research papers to promote statistical thinking

There have been numerous publications, workshops, and presentations at conferences suggesting specific techniques to use in class to promote statistical thinking. Hands-on activities get the students actively involved with the data. It also gives them an immediate experience with variability. However, these experiences tend to be simple activities that can be performed in a class period and can tend to “trivialize” statistical analysis.

Real-world data sets have unmistakable real-world import. They can be rich with statistically interesting features and can be selected to support particular curricula. Students, however, are not involved in any data production and the concept of variability remains hidden. In addition, most of these data sets are best explored using statistical software on a computer. Many introductory courses, particularly in mathematics departments, rely entirely on graphing calculators.

A third type of activity, simulation-based learning, again gives students direct experience with variability. In these types of activities, the instructor can control the structure of the data, thus the conceptual focus...
of the exercise. The disadvantage of these types of activities is that the data are not real.

Each of the three different types of learning activities can greatly enhance a student’s learning. Whether they can effect significant changes in the other two measures of effectiveness, persistence and attitudes and beliefs, is not as clear. Most learning activities illustrate a single concept. When the class moves on to the next topic, there is a new activity. In the limited time available in a college classroom, it is extremely difficult to conduct an experiment or observational study that can be carried through to completion. In addition, at this level, the students do not have the knowledge or skills to do this type of study on their own as an outside project. Studying the research others have done and presented as an article in a professional journal, allows the students to witness the development of the research as they learn the statistical techniques.

If an instructor has students who are all in the same discipline, research papers could be selected from journals in that area. There are several examples in the literature where journal articles have, for a number of years, been used in teaching biostatistics and epidemiology in schools of medicine and nursing. For some examples see Carter (1987), Mickey (1995), and Norton (1998).

If, on the other hand, the students come from a variety of disciplines, it is important to select papers of general interest. It is not difficult to find such papers. For example, a paper in *American Midland Naturalist* (Caro et al. (2000)) describes a study in which the authors count road kills in the Central Valley of California to study the effects of different types of human activity on the populations of medium-sized mammals. It is easy to understand, is only a few pages long, and has both descriptive statistics and hypothesis tests. Other papers that have been used successfully include “Transmission of Norwalk Virus During a Football Game” (Becker et al. (2000)) and “U.S. College Students Use of Tobacco Products” (Rigotti et al. (2000)). Journals that consistently have readable papers of general interest include *Journal of Marriage and the Family, Child Study Journal, Journal of Health Education, Journal of Personality and Social Psychology, and Developmental Psychology*. Since a single paper will not have an example of everything that will be covered in class, it is a good idea to have a couple papers. For instance, one could be an experiment and the other an observational study.
The papers could be used at the end of the course as a “wrap-up” to tie together the different topics that were studied during the semester. However, the students might still view the course as a group of separate activities until the papers are introduced. The preferred method would be to introduce the papers near the beginning of the course. Then, when a particular topic is studied, the students can see how that topic is handled in the research papers. By the end of the course, the students will be very familiar with the two papers and will have observed how a variety of statistical techniques are used in a single research study. Other resources of good journal articles for an introductory course and suggestions for their use can be found in Millard (2004), and Turner (1994).

5. Assessment

Since the use of journal articles in a statistics class can be a valuable learning experience, it is important to incorporate what the students learn from them into their assessment. Students can be asked to find a research paper in their field of study, or in an area that interests them, and write an analysis of that paper as a final project or in lieu of a final exam. It would be very important that the instructor approve the paper before the student begins his work to be certain that it is appropriate. There is a sample guide for a final project in the appendix.

In experiences with my own classes, I have found this to be a very effective tool. At the end of the course, I distribute a survey to the students listing every activity we did during the semester. I ask them to rate each activity on a five point scale from “not helpful at all” to “very helpful”. The first semester I used journal articles in class, 62 out of 67 students found journal articles to be helpful or very helpful in helping them understand the concepts presented in the course. No other activity received as high a rating. In the following semester, the students were able to choose between writing a critique of a journal article and taking a traditional final exam. Everyone of them chose the journal article.

For instructors who teach large lecture classes, and are unable to grade a great number of projects at the end of the term, an alternative method can be used. A paper of general interest can be distributed during the last week or two of class. During that time period, the students read the paper, ask questions, discuss it with each other, and become very familiar with that particular study. The instructor can then ask questions about that paper on the final exam. This technique allows the teacher to ask
questions that require higher level thinking than could otherwise be asked with traditional questions that have, at most, a few sentences to describe a problem.

6. Conclusion

Using journal articles in an introductory statistics class can be an aid in following GAISE guidelines. Real data from real research can be used which fosters active learning. When a research study is being followed through to completion, the focus is naturally on conceptual understanding rather than mere knowledge of procedures. The students see how the particular procedures fit into the entire analysis. Not only are they are developing statistical literacy, but they are learning to think like a statistician.

It is obvious that using research papers as a tool in teaching the introductory statistics course enhances learning but, in addition, it also helps meet the other two goals, namely persistence and attitudes and beliefs. Having observed a particular research study from beginning to end, the students are aware of the power and usefulness of statistics. Having seen the concepts they have studied applied to a problem or an area of research in which they are interested should certainly increase the likelihood that they will use their new knowledge and skills in the future.

Teaching an introductory statistics course that not only helps a student develop statistical thinking during the class, but encourages them to use what they have learned after the course is finished is quite a challenge. This can best be accomplished by a variety of learning activities including the use of research papers to illustrate the scientific method and to show how the many techniques discussed in class are part of this process.

Appendix. Suggested guidelines for final project

The instructor must approve the paper you plan to critique before you begin your work. If you turn in a project on a paper that has not been approved, you risk not having your project accepted! There is no minimum or maximum length to this project. Remember, I am looking for quality, not quantity. Basically, you are looking at a paper from a refereed journal and using everything you have learned this semester in reading and understanding this paper. Your written presentation should be in paragraph form using proper English. Listed below are some types
of questions you might want to address in your analysis. These questions are to be used as a guide only. You will not be able to answer every question listed for your particular paper and there may be other important issues to discuss that are not listed here. Feel free to include your thoughts or opinions about the study or techniques used.

The study

1. What were the authors trying to find out?
2. Was this an experiment or observational study? If an observational study, was it retrospective or prospective?
3. What type of data were collected? Discuss the type of sampling used, the size of the sample, and possible biases associated with the sampling.
4. Were any data obtained through simulation?
5. Did the researchers have problems with missing or incomplete data? If so, did this affect the results?

Descriptive statistics

1. Were there any graphic displays of the data? Did these enhance your understanding of the material being presented? Do you feel any of the graphic displays were misleading or could have been presented in a different way?
2. What summary statistics were used? Did these enhance your understanding of the material being presented?
3. Was there anything you would have added or deleted from the descriptive statistics presented?

Inferential statistics

1. Did the authors use confidence intervals or hypothesis tests?
2. Were any other types of inferential statistics used?
3. Which of the tests gave statistically significant results? State these results in words.

Conclusions

1. Based on the results of the tests of hypothesis and any other inferential statistics reported, do you feel the authors drew appropriate conclusions?
2. Was there any information on qualifications of the authors and who funded their research? If this research was funded by a grant, would the organization providing the funding have a financial interest in the outcome?

3. Include any other additional comments you have about the study and how it was conducted. Do you feel anything should have been done differently? Were there aspects of this research that you particularly liked or did not like? Were there any ethical issues that affected the study in any way?

References


