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ABSTRACT

Some suggestions are presented for teaching statistics. It is helpful to use a framework called backward instructional design, which consists of a series of steps that guide a teacher in constructing effective instruction. The first step in selecting the right pedagogy is to identify essential understandings and skills. Then, assessments that are the best measure of these understandings and skills need to be designed. Once these steps are completed, appropriate pedagogy to help students acquire and demonstrate their understanding and skills can be specified. A review of the literature yields some suggestions for college teaching that can be grouped in to categories of: (1) overcoming fear and anxiety; (2) lecturing creatively; (3) motivating students; and (4) using engaging discussions. Several other pedagogical tips are focused on getting students past four common roadblocks to learning statistics. The first goal is to gain students' attention. It is then necessary to establish a positive learning climate and then to foster deep understanding of essential ideas and principles. A final tip is to make effective use of technology. Sixteen threats to effective teaching are also identified. (Contains 11 references.) (SLD)

Some Pedagogical Tips for Teaching Statistics

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Paper presented at the 2001 Annual Meeting of the American Educational Research Association, Seattle. The author is appreciative of very helpful suggestions from Don Forsyth, Jon Wergin, and Paul Gerber

Introduction

My assignment in this paper is to review some pedagogical considerations in teaching statistics. Before beginning, in the spirit of having multiple perspectives in this symposium, here is mine. I do not consider myself a statistician, so what is presented is based on my experience as a researcher and evaluator, with most emphasis on the practical application of statistics. I am heavily influenced by 25 years of teaching statistics as part of research design, and by explaining to policymakers what statistics do, and, often more importantly, do not do. My perspective is that of a research professor in a doctoral granting, mid-level university school of education, and my mathematical skills are modest. My thoughts are a nonstatistical potpourri of research findings from generic studies on college teaching, recent research on constructivistic learning and motivation, backward instructional design, studies and advice about teaching statistics, my own experiences, and the experiences of some trusted colleagues with whom I consulted.

Backward Design

To begin, I think it is very helpful to use a framework called backward instructional design. According to Wiggins and McTighe (1998), backward design consists of a series of steps that guide a teacher in constructing effective instruction. The three steps are as follows:

1		2		3
What is worthy and required for deep understanding?	→	What is evidence of deep understanding?	→	What learning experiences and teaching promote deep understanding, interest, and excellence?

The first step is to determine what is it about statistics that is worth knowing and doing. This is similar to identifying targets, objectives, or goals. I want to stress the importance of deep understanding of essential ideas and essential skills, what Bruner (1960) refers to as the structure of a subject. It is identifying what is *worthy* of our time and effort. One approach to determining what is worthy is to ask a few questions while going through a list of possible topics:

- Is the topic, material, or skill enduring?

- Is the topic, material, or skill at the heart of the discipline?
- Is the topic material, or skill likely to be used?
- Is the topic material, or skill likely to engage students?
- Is the topic material, or skill focused on deep, as contrasted to simple or superficial understanding?

The second step stresses the importance of specifying the nature of the evidence needed to demonstrate deep understanding. This is comprised of classroom assessments, papers, portfolios, and projects. What is different here from most instructional models, indeed the organization of this symposium, and explains why the approach is called *backward*, is that assessment is considered *before* instructional activities. This is because the nature of the assessment forms the basis for deciding which instructional approaches and techniques will be most effective in helping students demonstrate deep understanding. Traditional instructional models put assessment at the end, as a consideration after instruction. For example, if you believe that deep understanding of measures of central tendency is best demonstrated through a performance assessment concerned with analyses and reporting of a set of scores, rather than regurgitating simply definitions, then instruction would be based on preparing students to do well on the performance assessment. To engage students so they see the application of principles to many different problems, practice on authentic tasks is preferred.

The first challenge to selecting the right pedagogy, then, is to identify essential understandings and skills. Second, assessments that are the best measure of these understandings and skills need to be designed. Once these steps are completed, appropriate pedagogy to help students acquire and demonstrate their understanding and skills can be specified.

Literature Review

With backward design as our instructional model, there is much to be offered through research on generic pedagogical tips for college professors. I have synthesized some of these in Table 1 from four excellent resources (Brookfield, 1990; Davis, 1993; Menges & Weimer, 1996; and McKeachie, 1999). Though this is far from a comprehensive list, it suggests some important areas to consider and some helpful techniques that have relevance to teaching statistics.

Table 1

Generic Pedagogical Tips for College Professors

Goal	Tips
Overcome fear & anxiety	• Use humor • Know students' names • Know students' backgrounds and interests • Use small group exercises • Provide low-stakes assignments • Evaluate students regularly in small segments • Allow retesting • Use diagnostic, low-stakes assessments • Structure success experiences early • Express high but realistic expectations • Create an open, positive atmosphere
Lecture creatively	• Know your audience and target examples to student interests • Practice proper pacing (10-15 minutes straight talking a maximum) • Distribute skeleton notes • Personalize large group lectures • Use questions to change tempo and direction • Use technology • Speak from notes • Use two minute breaks for dyad discussion • Use contemporary examples
Motivate students	• Present outlandish and controversial conclusions • Promote active learning with application exercises - get students writing, doing, designing, creating, and solving • Tailor examples to students' interests and backgrounds • Use a variety of instructional approaches • Establish challenging but realistic learning goals • Avoid student competition • Assign study questions
Use engaging discussions	• Ask application and interpretation questions • Begin with a controversy • Pull-in nonparticipating students

	• Redirect student responses • Assign roles to students • Do not grade student participation • Avoid definitive summaries • Protect minority viewpoints
Give helpful evaluations	• Provide relatively specific summaries of what is on tests • Provide specific, individualized, immediate feedback • Use a variety of items and questions. • Provide models of excellent, good, and poor work from previous semesters

There is some research that is specific to teaching statistics, though the results are mixed. The majority of recent research is focused on using more active learning and small group processes (Becker, 1996), but many of the studies are small in scope, using only a few or even one class. Given the effects of the instructor and group dynamics in each class, and differences in student objectives and measures, it is no wonder that general principles have yet to be firmly established. For example, one study, contrary to prevailing literature, found little difference in student learning when an activity-based, group-oriented instructional approach was compared to a more traditional format. However it did find that instructor and instructor/method interactions were important (Geske, Mickelson, Bandalos, Jonson, & Smith, 2000.) Another recent investigation that focused on student acquisition of inquiry and decision making skills, with use of collaborative small groups and authentic problems placed in context, found significant student growth over one semester, though this was based on a single class of 23 students (Derry, Levin, Osana, Jones, & Peterson, 2000). Scanlon and Morris (2000) show how computer-based learning environments can effectively provide realistic contexts and multiple representations consistent with constructivistic learning theories. If the focus is on affective outcomes and student motivation, humor has been found to be effective (Berk, 1996; Wilson, 1999), as has positive interpersonal relations between the instructor and students (Wilson, 1999), and the use of computer-based learning (Scanlon & Morris, 2000).

Some Pedagogical Tips

From the research, general literature, and my and others' experiences, I have come up with a list of pedagogical tips that seem to me to be worthwhile. These are organized around four pedagogical goals: get attention, create a positive learning climate, foster deep understanding of essential ideas & principles, and make effective use of technology. The tips are also focused on getting students past four common roadblocks to learning statistics:

1. Fear of failure and associated negative expectations.
2. Inability to integrate statistics with verbal meaning.
3. Pointless to learn information they don't need.
4. Regression to dualism.

Get Attention

The first and essential pedagogical goal is to grab and *maintain* student attention. Here are a few teaching techniques that can accomplish this goal:

- Use recent examples from everyday life, newspapers, controversies.
- Don't lecture for more than about 10 minutes without a break or change of pace.
- Tell students clearly that certain points, principles, or concepts are important (e.g., "this will show up on the midterm.")
- Present statistical "evidence" that is contrary to logic or most common beliefs.
- Use small groups and dyads to discuss application of concepts in short time segments, e.g., 3-5 minutes, then discuss with the class as a whole.
- Use a variety of instructional approaches in a single class period as well as in different class sessions; balance cooperative learning with individualized approaches.

Create a Positive Learning Climate

It is critical, from my perspective, to focus heavily on techniques that will establish a positive learning climate, one in which students are not strapped by fear, anxiety, loathing or intimidation. Rather, a relaxed atmosphere is needed, one in which there is respect for differing opinions, a willingness to help one another, and a sense of cohesion. Some actions that encourage such a climate include:

- Using humor.
- Using small groups early and often.
- Getting to know students' backgrounds, experiences, and interests.
- Knowing student names as soon as possible and using names while teaching.
- Providing individual attention as much as possible.
- Modeling desirable thinking skills as well as an enthusiasm for statistics.

- Being more of a facilitator of learning, less a knowledge dispenser.
- Show students success in the beginning to enhance self-efficacy and confidence.
- Provide a review sheet of what will be on exams two weeks in advance.
- Provide examples of papers and other products from previous semesters with your written comments and a grade.
- Offer make-up tests for students who want to improve their grade.
- Provide examples of test questions in advance with opportunities for practice and feedback.

Foster Deep Understanding of Essential Ideas & Principles

- Identify essential ideas and principles. Here are some of my favorites:
  - Immerse students in simple descriptive statistics. This lessens fear and provides a basis for complete understanding of the nature of data.
  - Attack dualism - students need to understand that solutions are not best addressed as simply right/wrong.
  - Graphs tell you much more than numbers.
  - Effect size estimates are more important than statistical significance.
  - Descriptive statistics are more important than inferential statistics.
  - The role of sample size in determining statistical significance.
  - Error in measurement as well as sampling.
- Use hands-on exercises when generating numbers.
- Always put numbers into words and graphs; use graphs extensively.
- Use examples to demonstrate importance of ideas and principles, examples of problems that can only be solved by statistics (e.g., life insurance profits).
- Utilize small groups to discuss examples and generate their own examples.
- Give short "assignments" to small groups of applications and ask them to come to a consensus; compare what groups come up with; ask them to explain and justify their answers.
- Enhance meaningfulness with authentic, contemporary examples and applications (e.g., use statistics to inform a decision about whether to spend money on cars or stocks).
- Emphasize that statistics is a tool for examining information, not an answer.
- Emphasize the subjective nature of "objective" statistics.

Effective Use of Technology

Balance the use of web-based instruction with direct interpersonal contact. Roadblocks to learning statistics are overcome primarily through interpersonal interaction, not by web-based assignments that isolate students.

- Teach students to use statistical software, especially how to construct graphs. My experience is limited mostly to SPSS, which students find very user-friendly.

- Have students enter real data - don't give them established datasets.
- Use relevant Internet sites as resources.
- Provide web-based tutorials.
- Use email to communicate with students.

Summary

In summary, in the spirit of my mentor Don Campbell, I have come up with a list of 16 threats to effective teaching. Perhaps some of these labels will stick and focus attention on the nature of effective pedagogy for teaching statistics.

Selection: Blaming student failure on the students.

Unfuzzy math: Failure to use warm and cozy metaphors for different statistical tests (e.g., teddy bear t-test).

Inadequate operational connection: Poor integration of technology.

Diffusion of treatmints: Liberal use of candy to bolster student ratings.

Statistical digression: Tendency to foray into obscure statistical detail.

Statistical significance sin: Thinking statistical significance is more meaningful than practical significance.

Superfluous superficialitis: Failure to teach sufficient depth of understanding.

Standard error of estimate: Having inaccurate expectations for student success.

Inexplicable vision deficiency: Using distorted graphs.

Mono-method bias: Using a single method or approach in teaching statistics.

Mono-trait bias: Thinking all students are basically the same.

Evaluation apprehension: Fear of receiving poor student rating.

Sinatra syndrom: Thinking that the only way is my way.

Resentful demoralization: Wanting to do most anything besides teaching statistics.

Mortality: giving up on students and/or yourself.

Peculiarly putative pedagogy: Assuming that there is one best way to teach statistics.

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