MY FIRST DAYS' LECTURES: PAST AND PRESENT

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1 Introduction

It was the first day of the Summer Quarter at Stanford, and I arrived early that morning to Sequoia Hall to move into Jerry Lieberman's office, which I knew I would be sharing with David Haley. The routine was the same as David and I had been through for the past several years, including the courses we were to teach. As I approached the east door of the building, David came out on his way to his first class. We hadn't seen each other since the previous summer, and he asked the natural polite question, "How are you?" I responded without thinking, "Nervous!" David, who had an international reputation for his excellence in teaching the master's level statistical inference course, displayed great surprise. He then replied, "I thought I was the only teacher who got nervous on the first day of class."

Since that meeting I have queried a number of my colleagues concerning their emotional state at the start of a semester or quarter. The vast majority of good teachers share this common nervousness. The thought of facing a new class creates a degree of fear. In fact, there are many of us who now wonder whether there are any teachers who are not, to some degree, uncomfortable on the first day.

After exchanging greetings with David I got the key to Jerry's office and settled in, reviewed my notes for class, and at 10:00 o'clock began my first day's lecture. It was the standard format that I used for the first lecture in every class I taught. I began by giving my name, the title of the course, my phone number and office hours. This information was followed by the name of the required text, and any reference texts. The next order of business was the structure of the class. I announced the dates of the two midterm exams, and that they would each contribute one-sixth of the grade. The final exam would contribute one third. Homework was to be turned in at the end of the next class after the assignment was made, and the homework would contribute the final third of the grade with one exception. If a student received a failing grade on the homework, they failed the course. The above comments were followed by "Any questions?"

Once this preliminary material was out of the way I was able to turn to the subject matter in the first chapter of the text, and finish the lecture having prepared the students for the evening's homework assignment. Given my nervousness about facing a new class of students, having a canned first lecture which I felt comfortable with provided me a bit of confidence.

It wasn't until quite recently that I realized there was another side I was overlooking. I never considered the fact that, if I was nervous, perhaps there was a degree of fear on the part of the students. And if there was indeed a fear in the students, what was the effect of my lecture on this fear? Of course there were students in the class who had a great deal of confidence in their ability to succeed, and had no fear. However those students who were less sure of their abilities would not be reassured by knowing that an easy way to fail the course was to fail the homework. They had yet to attempt to do homework and were undoubtedly quite insecure as to whether they could complete an assignment. Instead of worrying about my confidence with a new class, I needed to be concerned about the students confidence.

As I started thinking about ways I could structure the first day of class which would make students feel more comfortable about taking a statistics course, I realized that most students sign up for the class without a good idea of what statistics is about. In particular, they have no concept of the profession of statistics. If I want them to feel comfortable, and even consider a possible career in statistics, shouldn't I give them an indication of the types of activities they would be expected to be involved with? (I have since questioned how well other fields deal with this issue). I quickly realized that by moving directly into the text on the first day, I avoided ever creating a larger context into which the material of the course fit. I completely ignored providing an overview of the field of statistics.

As a consequence of the above concerns I decided to develop a "first lecture" which would meet the following requirements. It should provide the students with an overview of the field of statistics. The student should come away with a feeling of the breadth of activities in which statisticians are involved. The students should then understand where, in the overall picture the topics covered in the course fit. And finally, this introduction should motivate the students to want to learn more about the subject. Below is the lecture which I developed in my attempt to meet these requirements. My remarks will be obvious to the experienced statistician. However our students are not statisticians, and we need to gear our lecture to their level (another obvious fact we sometimes forget). Perhaps this paper will serve as a reminder.

2 The Lecture

2.1 Introduction

On the first day of a statistics course I am reminded of the freshman who took the INTRO. STAT. course in which he was required to do a project. To gather some data for his experiment he asked his dorm sponsor to buy him a bottle of gin. That Saturday night he proceeded to drink an excessive number of gin and tonics. The following morning he awoke feeling quite ill and recorded the results. The next Saturday he continued the experiment, this time with rum and tonic. Again, the following morning he awoke feeling miserable and recorded the results. The third Saturday he repeated the experiment with tequila and tonic and awoke Sunday morning with a bad headache and upset stomach. Again the results were recorded. At this point he wrote up the results of his experiment with the obvious conclusion. Tonic causes hangovers. I don't recommend either the experiment or the analysis.

2.2 What is Statistics?

We could start with the question, "What is Statistics?" But a person could equally well ask the same question about philosophy, biology, theology or art. What is art? There are many branches to art. There is the study of art history, art criticism, and the practice of art. Within each of these there are sub fields involving music, painting, ceramics and sculpture. Within music there are classical, jazz, opera, etc. Our cultural exposure to art has provided us with an understanding of the breadth of the field, and the fact that it would be impossible to develop a single course which would provide the student with an introduction to all of art.

In a similar vein, statistics is a very broad field, and has application in a large number of disciplines. To answer the question, "What is Statistics?" within a single lecture, or even within a single semester is an impossible task. I will attempt to place the content of this first statistics course in a much broader context. But to do so I paraphrase the question as "What is the role of a statistician on a research team?"

As a statistician who has had some consulting experience, primarily in the biomedical field, I suggest that there are (at least) five areas of a research project in which a statistician should be intimately involved. While experimenters do not always include statisticians in all of these stages (sometimes to the experimenter's later regret,) a properly prepared statistician will feel comfortable participating in every phase. These five areas are as follows:

1. Forming the Question
2. Designing the Experiment
3. Gathering the Data
4. Analyzing the Data
5. Communicating the Result

The above stages, or areas, are presented in an order in which they would naturally occur during the course of a study. However, it is important to note that they are interdependent. Certainly it makes no sense to design an experiment without first determining what question is being addresses. But not infrequently the question must be modified in order to allow for a feasible experimental design. Physical, ethical, or financial constraints can limit the actual question or set of questions that can be addressed in a particular study. We now turn to some examples which I have experienced, and which I feel demonstrate the important role a statistician plays on a research team.

2.3 War Stories

2.3.1 Forming the Question

Edward Deming [1] is a name recognized in industry as the father of Total Quality Management (TQM). It is his methods that were adopted by the Japanese in the 1960s and which are credited with establishing Japan's leadership in quality. This high quality is responsible for the great demand for Japanese automobiles which dominated the automobile industry into the 1980s. A story circulating among the TQM community during this time is as follows. When a problem arises in Japan they devote 90% of their time discussing the question, and then 10% of their time finding the solution. In the United States we spend 10% of our time on the question, and the remaining 90% on hunting for a solution.

The above story is perhaps an exaggeration, but the message is important as is illustrated by the following two examples.

2.3.2 California Assessment Program

Recently the State of California has introduced a new form of standardized testing to evaluate the performance of students through secondary school. This testing involves open ended questions allowing the students to demonstrate creativity.

In 1988, as the state was gearing up to administer these tests, a book containing a sample of mathematics questions and how they were to be graded was circulated to secondary school teachers [1]. Among the mathematics questions the following appeared.

> John has four place setting of dishes, with each place setting being a plate, a cup, and a saucer. He has a place setting in each of four colors: green, yellow, blue, and red. John wants to know the probability of a cup, saucer, and plate being the same color if he chooses the dishes randomly while setting the table.
>
> Explain to John how to determine the probability of a cup, saucer, and plate being the same color. Use a diagram or chart in you explanation.

I would like to have you spend a few minutes looking at this problem.

[At this point in the lecture I ask the students to individually work on the problem. I have them spend about five minutes on it before continuing with the lecture. I then proceed with the following statement.]

Now that you have all had time to look at the question, I would like to ask you to tell me, not what your answer is, but what problem you are attempting to solve. To begin, although John has four place settings, we don't know for how many people he is setting the table. Were you solving the problem for a table set for four, or for the table set only for John? What other possible interpretations of the question can you come up with?

HOMEWORK: By adding specific conditions to the above question, see how many different interpretations you can come up with.

As an aside,the book contained two sample graded answers. One treated the problem as setting a single place, but made a mistake in multiplying by 1/2 rather than 1/4 in the

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[1] For a description of the career of Deming see XXX

last step, although the student clearly had the proper idea. This student received half credit (a score of 3) for the question. The other paper received a perfect score, although the logic would have led to a probability of one had there only been two types of dishes, say cups and saucers, rather than the three. I cannot figure out any interpretation for the problem for which the logic of the solution would have been correct.

The point of the above example is that the question needs to be clearly defined before one starts trying to solve it. An important part of a statisticians job is to help the experimenter make this clear definition. The statistician should strive to fully understand the reason for the experiment and theory behind it. Frequently this will require spending some time reading about the subject area.

2.3.3 Toxicology Example

I was once asked by a pharmaceutical firm to help on a toxicological problem. My introduction to the project occurred at a meeting attended by the staff of the toxicology department and several vice presidents from the company, plus the chairman of the toxicology department from an area medical school who had also been called in as a consultant. The meeting began with one of the researchers from the company making a presentation, directed at the other consultant and me. I listened to the presentation for about five minutes, and then interrupted with the statement, "I'm sorry, but you are going to have to start back at the beginning again. I have no clue as to what you are talking about."

The initial reaction of the presenter was shock, followed by a sigh of relief as he realized that he was over my head, and hence knew more about the subject than at least one of the consultants. Perhaps this would make his job more secure in the eyes of his supervisors. As he started over on a much more introductory level (which I could understand), the chairman of the toxicology department leaned over and whispered, "Thanks, I didn't understand anything either!" As a statistician, I was not required to be an expert in the field of toxicology, and could ask *stupid* questions. He, on the other hand, was an expert in the field and I guess felt unable to display his ignorance. What an advantage it is to be a statistician and be able to ask questions. It is this advantage that makes statisticians valuable in the question forming stages of a research project. Frequently the questions we ask turn out to be related to factors not considered by the experimenter. Our questions help the experimenter better understand the project, and force a clear definition of the important issues of the study.

2.3.4 Rabbit Eyes

A number of years ago I received a call from a company that was doing a preliminary study of an anti-inflammatory drug to be used in the treatment of allergic conjunctivitis. (On a personal note, my ophthalmologist unwittingly gave me a prescription for the drug that resulted from this study this past year when I came down with a bloodshot eye.) The head of the unit had already gathered the data from the experiment, and asked me to meet with him so he could explain what had been done, and I could then perform the analysis.

The study was performed on rabbits, as their eyes are in many respects physiologically quite close to the human eye. The rabbits to be used in the study were challenged by injecting horse serum in their conjunctiva (the membrane that lines the inner surface of the eyelid) in order to create an allergin (make the rabbit allergic to the serum). One week later the rabbits were again injected with the serum, and then treatment begun. One eye of each rabbit was randomly assigned the treatment solution, and the other eye given the vehicle (the solution without active drug). Treatment was continued for one week.

The person in charge of the study was well aware that statisticians like lots of data. Hence, he gathered his data according to the following design. Five technicians who did not know which eye had been assigned the treatment each picked the more severe (redder) eye twice a day over a seven day period on each of two rabbits. Hence, there were a total of $5 \times 2 \times 7 \times 2 = 140$ observations for me to perform an analysis upon. The results were impressive. I was able to tell the experimenter that the technicians were consistent with one another in picking the redder eye. But when he asked me what I could say about the effectiveness of the treatment I had to admit that the data wouldn't allow me to answer that question. He had essentially flipped a coin twice (the two rabbits) and come up heads on each toss. There wasn't enough information to be able to demonstrate that the coin was biased (or the drug effective).

Unfortunately the type of problem illustrated above is not uncommon in research. Too often a study is run in which the data do not address the question of interest. It is important for a statistician to be involved in the study design to make certain that the data gathered will address the important questions.

2.4 Conclusion

I have listed the five areas of a study in which I feel a statistician plays an important role. The examples are intended to illustrate the importance of understanding the question, designing the appropriate experiment, and gathering meaningful data. Clearly, the data must be gathered and entered into the database with accuracy. Errors in data entry can lead to grave errors later on in the analysis.

The traditional topic of an introductory statistics course comes under the heading of data analysis. The analysis is the point in a research project where the statistician is in the spotlight. This is the area where the statistician has the expertise. However, it must be kept in mind that this part of the study usually involves a relatively small percentage of the total time that the statistician will put into the project. Since the introductory course devotes the majority of its time on this area the student needs to beware not to think that the field of statistics is limited to this one aspect.

There is one of the five areas that I have yet to mention – communication. This oft-ignored topic is, in my mind, as important as any of the others. There is no value in doing a study, no matter how well designed, conducted, and analyzed, if the results of that study cannot be communicated to the end user. For this reason I feel that a writing and oral component is an important part of each introductory course. If you fully understand a technique of data analysis, you should be able to communicate, in a clear way, the results of the analyses upon the gathered data. If you cannot, then learning various methods of analysis has been for naught.

2.5 Homework

The first homework problem, which has already been discussed, is to come up with different interpretations for the CAP problem.

As a second project I want to expose you to the detective work which is involved when we look at data. Below is the data from an *Unusual Episode* [2] Look at the data with the charge of trying to figure out the unusual event. For the next class prepare a list of questions that you would like to ask about the data. The data are presented first, by economic status and sex, and then by economic status and age. Within each set is the data for the population exposed to the risk, followed by the number of deaths, and then the death rate per hundred persons.

Population at Risk, Deaths, and Death Rates for an Unusual Episode:

By Economic Status and Sex

Economic Status	Population Exposed to Risk			Number of Deaths			Deaths per 100 Exposed to Risk		
	Male	Female	Both	Male	Female	Both	Male	Female	Both
I (high)	172	132	304	111	6	117	65	5	39
II	172	103	275	150	13	163	87	13	59
III (low)	504	208	712	419	107	526	83	51	74
Unknown	9	23	32	8	5	13	89	22	41
Total	857	466	1323	688	131	819	80	28	62

By Economic Status and Age

Economic Status	Population Exposed to Risk			Number of Deaths			Deaths per 100 Exposed to Risk		
	Adult	Child	Both	Adult	Child	Both	Adult	Child	Both
I and II	560	19	579	280	0	280	50	0	48
III	645	67	712	477	49	526	74	73	74
Unknown	32	0	32	13	0	13	41	0	41
Total	1237	86	1323	770	49	819	62	57	62

3 Summary

My *First Lecture* was created in an attempt to motivate students to want to learn about Statistics. My experiences so far indicate that it does a better job than my previous

[2] The original source of these data is unknown to the author. It was suggested to him by Dr. Julie Buring of the Harvard University School of Public Health, who obtained it in a course she had taken as a graduate student.

approach. I conjecture that one reason for this is that I am more excited about what I am saying.

I think it is important for statisticians to bring their own personal experiences into the classroom. Students like to hear about my experiences (War Stories), and my course evaluations from students request I include even more. These experiences become tools which make the material come alive. It is worth noting that in providing these experiences I am in line with the movement among leaders in the field of statistics education who are moving away from fictional data sets towards either realistic or real data (see Cobb [2]. Two texts that are considered on the leading edge of this movement are *Introduction to the Practice of Statistics* by Moore and McCabe [3] at the precalculus level, and *Mathematical Statistics and Data Analysis* by Rice [4] at the post-calculus level. As an alternative to Rice's text, Witmer [5] has a book which can be used to support a data analysis unit to run concurrently with the traditional introduction to mathematical statistics course.

The preface to Moore and McCabe lays out priorities for the introductory course, based on their concept of the role of statistics as applied in practice.

> The title of the book expresses our intent to introduce readers to statistics as it is used in practice. Statistics in practice is concerned with gaining understanding from data; it is focused on problem solving rather than on methods that may be useful in specific settings. ... We share the emerging consensus among statisticians that statistical education should focus on data and on statistical reasoning rather than on either the presentation of as many methods as possible or the mathematical theory of inference. Understanding statistical reasoning should be the most important objective of any reader.

Rice, in his preface, gives a similar view.

> This book is a consequence of my having taught a course at this level several times, and having come away each time feeling rather dissatisfied with what had been accomplished. It seems to me that the usual approach is a low-level introduction to a graduate course on optimality theory (which most students never take). This approach does not give students an overview of what statistics is really about ...
>
> I have tried to write a book that reflects my view of what a first, and for many students last, course in statistics should be. Such a course should include some traditional topics in mathematical statistics (such as methods based on likelihood), topics in descriptive statistics and data analysis with special attention to graphical displays, aspects of experimental design, and realistic applications of some complexity. It should also reflect the quickly growing use of computers in statistics. These themes, properly interwoven, can give students a view of the nature of modern statistics. The alternative of teaching two separate courses, one on theory and one on data analysis, seems to me artificial.

I support the move of both the above texts towards more data, and in particular more real data. However, each of these texts is only taking a first small step. Both argue that the introductory course should not be restricted to topic four (Analysis of the data) from my list above, but should branch out to expose the student to the broader field of statistics. However, each limits their discussion to at most topics three (gathering the data) and four. The respective tables of contents reflect the degree to which the texts reinforce such a restriction.

As with the academic disciplines of philosophy, biology, theology and art, I do not feel that it would be possible to teach an introductory course in statistics which treats, in any depth, all areas in which a statistician could (should) be involved in a study. But I do feel that it is important to indicate such breadth at some point during the semester. I have chosen the first day in the hope that the students will recognize this importance of statistics in research and, more importantly, in their daily lives.

References

[1] *A Question of Thinking: A First Look at Students' Performance on Open-ended Questions in Mathematics.* Sacramento: California State Department of Education, 1989.

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