IMMERSION IN DATA HANDLING: USING THE CHANCE-PLUS SOFTWARE WITH INTRODUCTORY COLLEGE STATISTICS STUDENTS

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This paper describes an intensive month long experimental undergraduate statistics course in which students were immersed in introductory data and chance problem situations. Students "played detective" and investigated data sets and probability problems using the Chance-Plus applications (Konold and Miller, 1994) as their principal technological tools. The level of students' critical analysis gradually improved throughout the course, as did their confidence to investigate data on their own in the future There are, however, trade offs, as some content is sacrificed using this approach.

It has been recommended that introductory college statistics courses abandon the recipe driven, statistical methods courses of the past, in favor of immersing students in a technologically supported data analysis environment (Biehler, 1994a; Rossman, 1996; Shaughnessy et. al., 1996). Such an approach requires instructors to take the risk of "throwing students into the deep end" by giving them context based data sets to analyze before they know some of the subtle concepts of statistics. It also requires that instructors make appropriate introductory statistical tools available, so that students can learn statistical concepts and relationships as they are playing detective with the data. Statistical tools for introductory students must be easy to use, flexible, yet powerful, and enable students to plunge into data exploration right away (Garfield1990).

Recently I had the opportunity to experiment with an introductory course in statistics and probability for a group of liberal arts majors who were taking classes in an unusual format, one course at a time in an intense four week block for five or six hours a day. These students could devote large chunks of time to exploring data sets. I wanted them to have access to a statistical tool that would produce summary descriptive statistics and allow them to create and explore a few powerful visual representations of the data. I also wanted tools that students could learn to use almost entirely on their own, with little up front instruction. The tools had to be easy to get started with, yet powerful enough to carry the students through the main goal of the course: students would conduct their own data analysis project and present their analysis to the class.

THE EXPERIMENTAL SOFTWARE

The Chance-Plus software (Konold and Miller, 1993), *Datascope and Prob-Sim,* had the potential to provide the type of data analysis environment I was seeking. *Datascope* allows for data entry in a quasi-spread sheet format, and possesses many (though not all) of the attributes suggested by Garfield. *Prob-Sim* is a probability simulation environment which allows one to create a population "mixture" of sets of objects in whatever relative proportions one would like, and then to sample, and re-sample, that population (with or without replacement). Inferences about the sampling distributions can then be made from visual displays of the data and from summary statistics of samples. Both *Datascope* and *Prob-Sim* are extremely easy to learn how to use, and both focus on a very few, albeit very powerful, data analysis tools. They are "bare bones," but very useful for students who are just beginning to learn about data handling.

DESCRIPTION OF THE COURSE

The principal features incorporated into this experimental introductory course were:

* Student Immersion in Data Sets
* Concentration on visual representations of data
* Emphasis on developing critical reasoning about data and graphs
* Use of *Datascope* to play data detective
* The use of *Prob-Sim* to run Probability Simulations
* Small Group Problem Solving
* Misuses of Statistics--developing healthy skepticism
* Extensive Student Writing--explanations of solutions; write ups of data analysis explorations; reflective reactions to articles; reflections on personal growth in statistical reasoning
* Self Assessments--of growth in concepts, data analysis, the use of the software, and feelings and beliefs about statistics.
* Use of *Statistics: Concepts and Controversies* by David Moore (1994)
* Final Statistics Projects by Pairs of Students

I had previously incorporated many of these features into introductory statistics courses, the principal differences this time were the use of the Chance-Plus software, and the immersion of students into large data sets from the outset of the course.

The class of 25 students met five days a week for three hours in the morning and two hours in the afternoon. We used David Moore's *Statistics: Concepts and Controversies* (Moore, 1994) for background reading, as well as a number of readings and articles on statistics and decision making under uncertainty, such as "Decisions, Decisions" (McKean, 1985) on the ideas of Kahneman and Tversky, "A Stochasticized World" (Davis and Hersch), and uses and misuses of statistics that appeared in newspapers and magazines. Most mornings were spent discussing data sets, introducing statistical concepts, creating various visual representations of data (e.g. stem plots, box plots, scatter plots, histograms, time plots), and conducting probability simulations using random devices (dice, spinners, tables of random numbers). There was very little formal lecturing in the class. Students worked on problems and data sets in small groups, shared their thinking and approaches with the whole class, raised and discussed questions based on daily reading and problem assignments. Students selected project partners during the first few days of the term, and began the arduous task of narrowing down on an appropriate project topic.

IMMERSION IN DATA

During the first afternoon class meeting, the students were introduced to Datascope in a computer lab, and asked to plunge into their first data set, which consisted of information from an administration of the Scholastic Aptitude Test (SAT scores). This test is required for admission to most colleges in the United States. For each state, the data set included mean scores for SAT verbal and mathematical aptitude, the percent of students who took the SAT's, the raw number of students who took the SAT's, and teachers' average salary. This SAT multivariate data set provides students with a number of possible choices to begin exploring data.

During the first few sessions, the students were able to identify some examples of spurious correlation that arise in the SAT data set. This created a great forum for debate, and enabled the students to address the tricky idea of causation vs. correlation themselves. They discovered that the teacher salary variable was inversely related to SAT scores, which might suggest that the higher their teacher's salary, the more likely students were to score lower on the SAT. However, upon probing deeper, students discovered relationships to other variables that accompanied the teacher salary variable, such as region of the country, or the number of students who took the exam in a given state. With the help of *Datascope*, these students were able to quickly search for relationships among many pairs of variables, isolate an instance of spurious negative correlation between teacher salaries and SAT scores, and address a big idea early on in the course.

In addition to the SAT data set, students investigated several other data sets in great detail prior to the analysis and presentation of their final project. Among these were data on the time intervals between eruptions of the Old Faithful geyser (in Yellowstone National Park), and a data set on high school students backgrounds and preferences, a set provided by the creators of *Datascope*.

THE IMPORTANCE OF PROVIDING THINKING PROBES FOR NEW STUDENTS

Students who are thrown into the deep end and asked to do some data analysis do not necessarily come to us readily equipped with adequate questioning skills to explore data in great depth. They tend at first to graph just one variable, note trends, graph another, note trends, and proceed rather haphazardly and piecemeal. They do not necessarily have an overall plan of investigation. The students in this class were no different in this regard, lacking critical data analysis skills at the outset of the course. I placed a heavy priority on gradually increasing students' ability to raise and explore their own questions. In order to "jump start" critical thinking and questioning, I provided a few initial probes for students to pursue when they explored the SAT data set. On subsequent data sets, however, students were placed in totally open ended situations where they had to raise their own questions, investigate them, and write up their findings.

REFLECTIONS FROM THE INSTRUCTOR AND THE STUDENTS

Datascope is easy to use so instructors can concentrate more time on helping students to develop their exploration and questioning skills than on learning particular aspects of the software. The questioning skills are probably *the* most important part of an introductory course in data analysis. The students were required to write up detailed analyses of data sets and explanations of their thinking. They also wrote reflective self assessment statements in the middle and again at the end of the course, describing their own growth and development in data analysis. Writing, reflecting, and questioning are extremely time consuming activities. Our quick entry into data exploration freed us to spend more time discussing, reflecting, questioning, and testing conjectures. *Datascope* and *Prob-Sim* permitted questioning and communication about data to play the pre-eminent role in the course.

I have previously incorporated student projects as a major requirement into introductory statistics courses, but the projects have often been rather surface level, lacking in data richness or depth of analysis. While there were still a few surface level projects in this experimental course, it was more the norm for the pair teams to tackle complicated multivariate data sets in their projects, and to explore the data in much greater detail than in my previous experience with students' projects. Some examples of projects: an analysis of data from the state department of health on infection rates of HIV virus from several nearby counties within the state; an analysis of drug and alcohol usage among college students; an in depth analysis of the many variables that contributed to the success or failure of a school sports team; an analysis of multivariate census data from several counties within the state.

As instructor of this experimental course, I was not able to gather as much "objective" research data on the students' growth and understanding as I would have liked. However, the students assessed their own growth and understanding of data handling issues throughout the course. In addition to weekly journal entries in which they reflected on their own learning, they wrote midterm and final self assessment statements that pin pointed their own areas of growth, and areas in which they felt they needed further work and understanding. These self assessment reflections provide a picture of their growth through the course.

JC--I figured I would pretty much just learn some formulas that would make me able to calculate probabilities...however, we also dealt with how to critique given statistics and how to choose which are relevant and useful. My work shows my growth during this class, (especially on) the High School Survey write-up... I am confident that I could successfully work with large amounts of data in the future.

DS--I now have new questions about (probability and statistics) that I could not have formulated before. Most importantly, it gave me the ability to set up experiments and surveys, and to critically evaluate them.

DL--I can't say that now I can sit down with one of your data sets, and for sure come up with an answer, but instead of giving up, I can come up with possible explanations.

PE-- My mid-term self assessment made me think I wasn't so good at "sleuthing". With practice, I feel more comfortable, yet still not sure if I dig enough or ask enough "why" questions. But, generally, I thought my (computer) lab skills improved immensely.

SB--One thing I didn't enjoy about this class was the High School Survey lab. There was way too much information, and I felt the assignment was too vague. I was so overwhelmed that I thought the best way to explore the data was to come up with specific questions....

BB-- The project was a good addition to the course, (but) could have been more effective if we had covered the statistical tests early enough to use them effectively in our project. I would have liked to apply these tests to become familiar with when they are applicable.

KH--I feel this class has taught me how to better represent and interpret data. I was forced to learn to use computer programs for my project....The project would have been more useful if we had to apply some of the recent things we learned, such as confidence intervals, chi-squared, etc.

JA-- I feel as though I am walking away from this course with a new perspective on probability and statistics. I now look at data and "evidence" with a new sense of skepticism--does this data really support what they are saying?

SP-- These programs (*Datascope* and *Prob-Sim)* have been practical because they have allowed me to visually see the data entered in many different forms. Having a final project has enabled us to do independent research on an enjoyable subject of our choice.

MP--The highlight of the class was our partner project/presentation. I feel that the knowledge of generating tables and graphs through the computer programs will be valuable for future classes.

LL-- I feel confident that I can analyze data at a much deeper and more comprehensive level. I feel like when I encounter data in the real world and in my psychology classes, I will know what to look for and what to do with it. the Project was a real good hands-on learning experience for dealing with lots of raw data.

IMPLICATIONS FOR FUTURE TEACHING AND RESEARCH

From their comments, many of the students exited this course with greatly enhanced beliefs in their data analysis skills, wanting to learn more about statistics. Although it is a good beginning, this one course is not sufficient to build the level of understanding of data and chance that our students need in order to investigate data on a deeper level. We sacrificed the building of strong connections to probability models in favor of having students spend more time exploring data sets with the software, and in researching, analyzing, and presenting their projects. While everyone--students and instructor alike-- felt this was a good choice, at the end the students did recognize the trade off (see comments), and some of them pined a bit for the traditional statistical tests material in their reflective comments. A two course sequence is needed, in which students are immersed in data in the first course, and then begin to build healthy connections to theoretical probability models in the second course (Biehler, 1994b). This teaching experiment suggests that it would be an enlightening research project to conduct a multiple case study, monitoring a sample of students in introductory statistics using the Chance-*Plus* (or similar) software while carefully documenting their growth and development in statistical thinking and data analysis.

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