STATISTICAL CONSULTING IN ARCHAEOLOGY: DIGGING FOR REAL DATA

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Traditionally, statistical consulting is used as a reward for students who have passed through the rigors of formal coursework by giving them experience in the application of their skills. Consulting in archaeology allows students an opportunity to apply their knowledge to a real field. Examples from consultation and lectures on statistics at recent expeditions in Israel have evolved into a course, Archaeometrics, intended to motivate non-statisticians and statisticians alike through preparation for consultation and participation in an excavation. Application of consulting to field work has benefited not only teaching and students, but research. It has stimulated new ideas about gathering and analyzing archaeological data and created new problems to challenge statisticians.

Consulting can be used as a vehicle through which students gain real world experience in the field of statistics. Unfortunately such experiences are hampered, especially at small undergraduate colleges, by a dearth of opportunities. This paper describes how the field of archaeology, and a course designed as an introduction to both archaeology and statistical reasoning, can provide training and opportunities for the application of statistical theory to an ongoing research project. Opportunities are provided for statistics students to learn the basics of consulting by functioning as consultants, and for humanities students to learn the benefits of a statistical perspective. The use of archaeology is simply one example that can be used as a paradigm to provide training for those who will consult and those who will be consulted. The present multidisciplinary environment in most universities is the perfect setting for this type of collaboration. And the increased interest of funding organizations for supporting multidisciplinary efforts makes this an ideal time to undertake such projects.

One of the problems which is addressed by involving students concentrating in statistics in archaeology is that of finding projects in which the students may consult as undergraduates. While students studying statistics at large research institutions often have consulting opportunities, the reality for most small undergraduate colleges is that students learn theoretical statistics and have few opportunities to apply their knowledge. For this reason, many students consider statistics to be just another branch of mathematics. Lack of a consulting experience, which is a chance to apply the tools of statistics, leaves them without an appreciation for the artistic side of statistical reasoning. They learn the

formulas and theories of analyses, but have no opportunity to become involved in planning a study, gathering real experimental data, nor having to present the fruits of their analyses to professional audiences.

A survey conducted by the Conference Board of Mathematics (Loftsgaarden, Rung, and Watkins, 1997) provides some disturbing data which might, at least in part, be the result of this lack of opportunity. The survey indicates that of 14,294 baccalaureate degrees in mathematics awarded in the USA during 1995, 38.0% were awarded by four year colleges, 28.5% by institutions offering terminal Masters degrees , and 33.6% by Ph.D. granting institutions. But in considering the data on Bachelor degrees with a statistics concentration, 81.0% are awarded by Ph.D. granting institutions, 13.6% by terminal Masters programs, and only 5.3% at four year colleges. Alternatively considered, 13.4% of the baccalaureate degrees in mathematics and statistics at Ph.D. granting institutions are awarded in statistics, whereas the comparable percentage at four year colleges is only 0.9%. Simultaneously with the low production of students concentrating in statistics at the undergraduate level, an increase in demand is being created for statistics educators in these same institutions with the trend to require all undergraduates to take a course in statistical reasoning at some point before graduation.

A course designed for the Claremont Colleges (specifically, Pomona College and the Claremont Graduate University) entitled “Archaeometrics” was originally designed as a response to this trend. While the need for coursework in statistical reasoning is often apparent, the courses traditionally used to present the material magnify the fear of mathematics (and through naïve association, statistics) that many humanities majors seem to suffer. Archaeometrics was designed as a way to teach these math-anxious students statistical reasoning using data which they understand, and in which they are interested. While the course has been very successful on that front, the design of the course and its relationships to archaeological expeditions at Tel Safi, Tel Harassim, and in the near future Tel el-Farah South, Israel have created opportunities for many students of mathematics with some statistical training to apply their knowledge in a field.

Many of the assignments in Archaeometrics are designed to replicate real world experiences. The first assignment is designed to force the students to think about designing an experiment with little time and limited resources. The students must spend time at a local field station where a mock archaeological mound, or tel, has been created. The students, in small groups without previous preparation, are required to design a

surface survey and carry it out with limited resources and serious time constraints. They are then required to create a list of questions addressing what they thought the focus of the exercise was, how their particular experiment was designed, whether the data gathered helped resolve the initial questions, what flaws became apparent within their design, and what changes they would make in the future. As a result, the students learn first hand the importance of asking the right question, and how the inception and design of a project govern its ability to answer that question.

The second assignment again separates the students into groups in which they design an experiment where they must record and then analyze their data concerning regularity of customers arriving and/or departing various local businesses who enters (in terms of age, gender, etc.), what the customers do while on the premises, etc. The students are encouraged to address the appropriateness of a Poisson model for their data, as this model plays an important role in the generation of archaeological information .

For the assignment, the students must carefully formulate a question they wish to answer prior to designing the experiment. They must also design the experiment based on such factors as their personal schedules and the hours of the various businesses available to them. While the project is carried out by a team, students are responsible for their own analyses and papers, which must include many of the graphing techniques studied throughout the semester.

By the time of the third assignment the students have had some training in designing research projects, carrying out experiments, and analyzing resultant data. The third project therefore focuses on grant writing. The students must write a grant application to conduct a hypothetical excavation. Included in the proposal must be the justification for the excavation, the goal and importance of the project, and the methodology they will employ. Managerial considerations including how and when the excavation will be conducted, as well as a list of the staff, supplies, and of course, a budget must also be addressed.

While the assignments in the course are not carried out for an actual client, they do provide some idea about the processes involved in, and different stages of, the consulting experience. Perhaps the appealing characteristic of the course is its relationship to a real archaeological excavation, and a means with which to participate in it. Because the course is connected to the Claremont Colleges, students gain access to archaeological projects which are conducted in Israel. Training in the course is not a prerequisite for

volunteers on the excavation. However, the course does provide a means through which students can find grant monies. The excavation experience also provides students with opportunities to further academic and career goals which were introduced to them through the course.

An archaeological excavation is a perfect forum for the application of statistical theory in a consulting environment which is fun, exciting, and which also provides the learning experience of travel and discovery. It is an experiment embarked upon to answer questions covering historical and archaeological topics which, in the Middle East, are often related to religion and modern politics. It is an area where large quantities of data are gathered in a short period of time under rather difficult circumstances (heat, wind, and dirt to name a few). Issues in which statistics can play an important part include the decision of where to excavate and which archaeological techniques to use in order to answer specific questions. Methods of data gathering, recording, and processing as well as determining an appropriate method of statistical analysis of those data, must also be addressed.

In many cases, statistical consultants are brought into a project only late in the experimental process when experimenters find their own knowledge of statistics to be insufficient for their needs. As a result, consultants are often faced with the task of salvaging an experiment rather than being given an opportunity to participate in it. Archaeological projects have already provided situations where students have been able to test their statistical skills through early involvement.

Because the survey of Tel Safi and proposed excavation of Tel el-Farah South are new excavations, they provide opportunities for students to enter an area of consulting on the ground floor. Since statisticians will be involved from the beginning of the process, they will be able to help determine which questions can and cannot be answered statistically and aid in the design of the experiments. Consultants will also be able to provide suggestions on how to gather data, address problems with the recovery procedures, and in particular help to improve the way data are recorded especially exciting in light of new uses of computers and the associated technology in processing of the artifacts.

Both Tel Safi and Tel el-Farah South were excavated in the late nineteenth/early twentieth centuries, without the input of statisticians or any of the recent developments in the field of archaeology. Despite the flaws in the previous excavations, there still exists a

large amount of data which might be of value. Thus, how to salvage these data while excavating for new information is an area where a statistical consultant's help is more than welcome.

Another example is the site of Tel Harassim, a project with limited funds. Despite this situation, the excavator has carefully gathered a large body of data. Recently, statisticians and their students have participated, and continue to participate, in that excavation. Tel Harassim is another environment in which statistical reasoning can be applied before all the data have been gathered. This creates an opportunity to compare the classical archaeological methods of data gathering, recording, and processing with innovative techniques which incorporate modern technology and statistical methodology.

An important yet often overlooked benefit from the course is its impact upon those students who will become "consultees," the future consumers of the statistical consultant's product. Many companies which employ consultants, and others that should, populate their management teams with graduates from four-year colleges, and in particular students from such colleges who concentrate in the humanities. These are the future customers of statisticians. The use of statistical consulting techniques, both in the class and on the excavation, provide a completely different experience for these humanities oriented students. Through class assignments and practice on the excavation, non-mathematics students learn first hand what and how a statistical approach contributes to a research project. The goal of these activities is to teach the students where and when in a project such expertise is most beneficial. If humanities types, who in the future will manage corporate projects, learn in college how to benefit from such expertise, it is more likely that they will incorporate this training regularly throughout their careers. Furthermore they will be familiar with the jargon and thought processes involved so that they can better understand what a consultant has to offer and will have a better sense of the questions to ask of their consultant.

While the Archaeometrics course discussed above applies statistical reasoning to archaeology specifically, it can be modified in a number of ways to conform to the interests, talents, and fields of the students and faculty involved. The multi-disciplinary environment present at most academic institutions promotes and supports this kind of endeavor. The administrations at both Claremont Graduate University and Pomona College have provided support in a number of different ways, but most importantly with their enthusiasm. The world is moving towards a multi-disciplinary approach to problem

solving. The sooner people are trained to think in this way, the more effectively they will be able to apply such methodology.

REFERENCE

Loftsgaarden, D. O., Rung, D. C. and Watkins, A. E. (1997). *Statistical Abstracts of Undergraduate Programs in the Mathematical Sciences in the United States: Fall 1995 CBMS Survey*, Mathematical Association of America: Washington D.C..