Teacher's Corner

Community-Based Projects in Applied Statistics: Using Service-Learning to Enhance Student Understanding

Rob ROOT and Trisha THORME

Community-based projects can enhance student understanding of descriptive statistics and of the use and value of inferential statistics. This article relates the authors' experiences with and reflections on three semesters of elementary college-level statistics courses that included an optional service-learning component. Reasons to try community-based projects in mathematics, and suggestions for identifying and implementing them, are offered.

KEY WORDS: Experiential education; Pedagogy; Statistical teaching.

1. INTRODUCTION

Statistics and mathematics professors everywhere strive to bring students to an appreciation of the value and import of the material they teach. This is especially important in an applied statistics course, one designed to introduce students to the basics of practical statistical thinking. The authors have found that introducing a voluntary service project into the course is a particularly effective tool toward this end, one with a number of other positive ramifications.

In this article, we describe service-learning, present our thoughts on its recent acceptance into the curriculum at large, and its fit with this course. We offer an annotated chronicle in the hope that the reader can discern good practice. Some observations on the applied statistics course that arise from our experiences follow, and we conclude with some thoughts on the paths service-learning could take in the mathematics curriculum more broadly. We believe that service-learning offers many unique opportunities in the teaching of statistics and mathematics, and we describe how our approach has begun to exploit those possibilities to enhance the teaching of descriptive statistics and statistical inference.

1.1 Service-Learning

Service-learning, a branch of experiential education using service or community experiences as an educative tool, is gaining ground in K–12 and higher education. This concept emerged in the 1960s and early 1970s and has steadily evolved over the intervening years (see the book by Stanton, Giles, and Cruz 1999 for an extended discussion). The explosive growth of community service on college campuses has had a ripple effect in the American classroom in the form of an increase in service-learning opportunities, especially in the last ten years. This activity has largely been outside of mathematics and the natural sciences (Ritter-Smith and Saltmarsh 1999).

The central pedagogical idea of service-learning is essentially that of experiential education (Kolb 1984), that learning takes place through reflection on experience, in this case service in the community. This poses the question of the proportions of service and learning (Sigmon 1996). Our favorite definition of service-learning is that "service, combined with learning, adds value to each and transforms both" (Honnet and Poulson 1989, p. 1). We would certainly associate both value and transformation with our experience.

This flies in the face of the preconception that mathematics and the hard sciences are not fertile subjects for service-learning opportunities. Our efforts suggest the potential for service-learning in the mathematical sciences curriculum has only begun to be plumbed.

1.2 Context for Our Project

We came together to implement service-learning pedagogy in an elementary college-level statistics class, since we were aware of this approach to learning in other disciplines. The authors are a mathematician (Root) and the (then) community outreach coordinator (Thorme) for a small, selective liberal arts and engineering college, Lafayette College. We were aware of the increasing interest in this pedagogy in other disciplines and considered trying it out in statistics over the summer of 1998. Each of us found special appeal in different aspects of the undertaking. Incorporating community outreach in the curriculum had obvious appeal to someone charged with coordinating student volunteers for community service.

The opportunity to expose students to statistical problems in a real-world setting was of great interest to a mathematician who was searching for experiences to deepen his students' understanding of and appreciation for statistics as they might apply it. The following quotation from Bradstreet (Bradstreet 1996) summarizes Root's experience, as well.

> Students often are able to manipulate definitions and algorithms with apparent competence, and yet not reveal, to their teachers or themselves, that they would not know what to do if faced with a real world problem.

One aspect of the course at Lafayette College made service projects especially appealing. The course is designed for the

Rob Root is Associate Professor, Department of Mathematics, Lafayette College, Easton, PA 18042 (E-mail: robroot@lafayette.edu). Trisha Thorme is Coordinator, Community-Based Learning Initiative, Princeton University, Princeton, NJ 08544-1100 (E-mail: tthorme@princeton.edu). The authors gratefully acknowledge the contributions of the students in the courses described and the collaboration of the Third Street Alliance for Women and Children, particularly Jaqui Carr-Levine, the staff member in charge of research. This article benefited from particularly insightful and constructive review by an associate editor and two reviewers for *The American Statistician*.

second semester of college, but the audience ranges from first-year economics and business students, some of whom have very weak mathematical backgrounds, through upper-class engineering students, some of whom have taken a great deal of college-level mathematics. Thus, service projects offered an opportunity to challenge virtually all students, despite the diversity of quantitative skills and confidence.

Web-based service-learning resources (http://csf.Colorado.edu/sl/syllabi/math/hampton107.html; http://www.fiu.edu/~time4chg/Library/ideas.html) gave pointers on how to incorporate service-learning in statistics classes and we decided to experiment.

There are some compelling reasons to adopt service-learning in teaching mathematical sciences, and particularly in service courses in statistics.

- Community service is a natural venue for active learning. Students must engage the material at a much more profound level than in textbook reading and exercises. The students are clearly more impressed with the utility of the concepts they are learning, and more aware of the nuances and difficulties of their application, when they work through a project with real-world consequences. These consequences bring import to the work done and the conclusions drawn that academic exercises cannot equal.

- Successfully completing a service project involves integrating large portions of the material covered in the course. Although other projects included in this course are useful integrative tools, they do not offer the open-ended possibilities or the breadth that a service project can afford. Real-world problems often contain unexpected difficulties or require tradeoffs that exercise students' intellect or judgment in unanticipated ways.

- In community service the students by definition encounter real-world problems (Duke 1999). This can lead to thinking about the boundaries, nature, and production of knowledge (Kleinman 1999, pp. 30–31), and how knowledge (in this case statistical information) is used and abused every day in the workplace and in media of many kinds. As Bradstreet suggests (Bradstreet 1996), this is particularly appropriate in a course in statistics for nonstatisticians.

- There is a small but significant segment of the student body with an abiding interest in and enthusiasm for community service. These students jump at the opportunity to integrate their work in the community into their coursework. Their enthusiasm is contagious and can result in a powerful experience for them and their teammates in both an academic and a personal sense. Students who choose service-learning tend to be bright and motivated (Eyler and Giles 1999).

- In the authors' experience, the students most interested in community service are disproportionately women. A service-learning project offers to these women a compelling reason to master a subject that many find intimidating, and that many do not envision as having a valuable place in their future. This opportunity is all the more valuable as it can be offered without any sense of favoritism. Men do not perceive the opportunity to do a service project as disenfranchising them; in fact, men participated in all the community service projects that were completed, with two of the teams being all-male.

- Finally, the opportunity to do good by doing well in the classroom is appealing to faculty as well as students. Service-learning affords an opportunity for faculty with serious time constraints to allot a portion of their pedagogical time to supporting the surrounding community.

2. OUR PRACTICE: A CHRONICLE

2.1 Laying the Groundwork

We had an intuitive sense before we started of what elements a successful project for students, faculty, and community-based organizations (CBO's) would contain. Our experience and the literature bear out that these are: a direct tie to the course material; an opportunity and a challenge for students to practice what they are learning and reflect on their experiences; and community voice into what form the service will take (Kleinman 1999, p. 33). We realized that students need to discuss their service projects during the process, not just at the beginning and the end (Eyler and Giles 1999, pp. 199–200; Lovett and Greenhouse 2000).

It seemed to us that to achieve a service-motivated learning experience required that the students volunteer for the opportunity. In our three attempts, we have found means to allow the students to include service-learning without requiring that all students complete a service-learning project. Student resistance to community work can hinder learning, harm the community, and inhibit student willingness to engage in community service more generally (Stukas, Snyder, and Clary 1999). In order for a community-based project to be successful, the students must see a clear link between doing the project and their goals, such as their career aspirations or the desire to see immediate results from their academic work.

We offered several possible project topics that would fit with a variety of student interests. Before designing the class assignment we identified several prospective areas for investigation with local CBO's. In making these choices, we needed to be careful that the projects would be substantial enough to be worthy of inclusion in the course, while not overreaching the statistical capabilities the students would develop over the semester. At the same time the results had to be useful to the CBO with which the project was undertaken. Students can complete a variety of useful statistical studies without delving into areas too sensitive for them or too temporally or financially urgent for the organization. It is a good idea to attempt to achieve this delicate balance in cooperation with an organization that already has a good relationship with the school, especially for the first time.

Thorme took the initiative in finding most of these opportunities, based on her professional relationships. Root was able to provide some suggestions based on personal relationships, but the most, the best, and the longest-lasting opportunities were culled from Thorme's extensive contacts in the community. Thorme was able to vet ideas, making sure that possible projects matched the goals and content of the course. Anderson and Sungur (1999, p. 133) found that students with strong community ties are not hard to find and can help identify appropriate opportunities. If funding can be obtained to employ these students

in work-study, they can "coordinate activities, contact agencies, organize data, and meet with faculty members." Anderson and Sungur cautioned: "An individual faculty member could implement service-learning through careful, advanced planning."

2.2 Our First Time Through

Our first time out we made a service project an option. Root presented the service project as an option that a student could use to replace his or her lowest hourly exam score for the semester. Our principal rationale for this motivation was that this course enrolls a significant segment of students who are not confident in their use of mathematics, and who have a history of underperforming on exams. Thorme made a presentation in class to emphasize the utility of the project to our community partners. This project was entirely optional, otherwise there was no project at all, just exams. Participants in the service project were allowed to drop their lowest exam score. We thought this would appeal to students who have a more collaborative learning style or who do not test well. The project could be done as a group or alone. We designed the project this way so that we could provide the opportunity without restructuring the course curriculum.

As we had anticipated, the service option appealed to a variety of students concerned about their exam performance. As the semester progressed, almost all the conscientious students found that their fears were unfounded and dropped out of the project. Students with reason to be worried about their grade stayed involved. As a result, the single group that completed a project did uneven work (one person carried the group) and completed a mediocre report. The group studied the use of a swimming pool at a community center. The study substantiated that the seniors using the facility were deriving concrete health benefits (relief from arthritis, aerobic exercise) that they would otherwise be unable to afford. The data were collected by interviewing the pool-users so late in the semester that there was little time left to analyze the results. The report was purely descriptive and its conclusions apparent, but even so this modest quantification helped the community center justify its aquatic program and maintain funding to keep the pool open.

It was clear from our experience that to get better results we needed to find better motivation for the students. We needed to continue the interest of the most conscientious students in the project throughout the semester, and pace the students' work on the project so that it did not get rushed at the end of the semester.

2.3 Our Refined Attempts

In our subsequent offerings of this course we tried to make the service-learning a more integral part of the course, and to make the improvements described above. The syllabus was changed so that everyone had to do a group project integrating the material covered in the course into a statistical study. Literature on statistics education suggests that students learn better working on problems and projects in small groups (Garfield 1995, p. 30). A service project was still an option. At the time the project was assigned, Thorme once again put forward a presentation to induce students, especially those who had experience in community service, to participate in a service project. We found that this produced more and better projects than our first attempt, and our participation rate increased the third semester because we were able to say that the distribution of grades for groups doing service projects was higher than for groups that attempted to find their own issues to study.

In order for the students to appreciate the work they were being asked to perform, the project was not assigned until the students had a broad exposure to descriptive statistics, and had begun to be introduced to the design of experiments and surveys. This was about four weeks into the semester. We found the material covered to this point was adequate so that the students understood how to collect data and what they might do with it afterwards. The course covers inferential techniques only in the last three weeks or so, but our experience suggests that data that yield a good description of a situation is usually amenable to an elementary inferential technique.

The students were permitted to choose their own groups for this project. They had done two shorter projects in groups of two; they were required to pick a different partner for each. Thus, the students were assured of having a little knowledge of their classmates' ability to work in groups before committing to a team for their largest project of the semester. One advantage of choosing a service project was the possibility to work in a larger group. Students who did not choose a service project had more latitude in choosing the topic of study for their project (the only limitation was the consent of the instructor), but could work in teams of no more than three. Although some service projects were large enough in scope to merit a team of five, some students preferred this option simply because it relieved them of the responsibility to choose their own topic. An intermediate option was to contact a professor whose research interested the team, and offer to study a question arising in the professor's research.

It was important to require reports throughout the semester to keep the groups on task and up to pace (Garfield 1995, p. 32). This allowed the instructor to aid the students in learning the statistics and guide them in applying it appropriately. The deadlines for service projects required more flexibility, but the interaction with the community-based organizations encouraged groups to keep a good pace. Our goal was for these reports to serve as opportunities for reflection not just on the statistical processes but the importance of the work for the community. We hoped that a larger view would motivate the students to improve the project. We had some success on this front, but observed that written reports handed in without discussion did not encourage big picture reflection. Our best results, both statistically and in terms of appreciating the significance of the work, have come from groups that discuss interim reports with the instructor.

In addition to the final report (due the last day of class) the students had to turn in three reports:

1. An initial report that includes the team members' names, the minutes of a meeting with a contact person at the CBO, and a description of the issue that the study will address. (Due two weeks from the assignment.)

2. A design for the study that describes how the data will be collected, and includes the questionnaire to be used (if there is one). (Due two weeks later.)

3. The next report includes the raw data with an assessment of its quality. This assessment is one of the most important aspects

Course Schedule — 14 Week Semester			
Classroom Content		Project Assignment	
Weeks	Material	Weeks	Goal
1–5	Descriptive Statistics	3–5	Choose Team/Project (1st Report due)
6	Experimental Design	6–10	Design Study
7–9	Probability		Begin data collection (2nd Report due)
10	Sampling Distributions		
11–14	Inference	11–12	Finish data collection (3rd Report due)
		13–14	Analyze & Summarize (Final Report due)

Figure 1. The progress of projects in parallel with the curricular development of the course.

of the project. Preliminary descriptive graphics are helpful at this point to aid the instructor in guiding the group to appropriate analytical techniques. (Due three weeks later.)

See Figure 1 for a schedule that shows the progress on the projects in parallel with the curricular content of the course. The final report includes an introduction based on the initial report; a description of the data collection that is based on the second and third interim reports; and analysis of the data, conclusions, and recommendations that are new material. The dataset itself is typically an appendix to the final report.

2.3.1 A Sample Project: A Descriptive Study

One team worked with a homeless shelter/community center. The team contacted the employee responsible for gathering data and assembling statistics that demonstrate that the agency is using its funding effectively.

The team was asked to administer and analyze an ongoing survey regarding how children's behavior changed as a result of participation in a social skills curriculum that was part of the childcare work of the center. The data collection was intended to be a census; the college students questioned parents as they picked up the children and got a much higher response rate to the survey than the center had achieved in the past, when the survey instrument was sent home with the children. The center wished to assess whether the children involved in their program were improving their social skills, so the students were faced with comparing their data with the data collected in prior surveys. They had to consider the effects of voluntary response and associated lurking variables on the data. This project involved only descriptive statistics, but the students took advantage of the opportunity to carefully scrutinize the situation, and to make recommendations to the center.

Results from this project figured prominently in the center's United Way goals and evaluation presentation, a critical step in obtaining funding for the program. It seems fair to assert that the students made a lasting contribution to the center's ongoing work.

2.4 The Effect on the Class

The community service projects assisted even the students who were not involved to see the relevance of the techniques and ideas presented in the course. The students doing these projects put in a great deal of time, and led the entire class to higher levels of involvement. Based on conversations with colleagues who have used semester projects, but allowed the students to create their own topics or choose topics from a list of choices, the quality of projects in this class overall was better. This may have been in part because Root encouraged students not interested in community service to seek ideas from other faculty members. Anecdotal evidence suggests that some of the projects that were conceived by the students in the course including service projects attempted to answer questions that were more important, gathered higher quality data, and analyzed and interpreted results more completely. The student evaluations of this course were very positive, although the written comments did not indicate that the semester project was on the minds of the students as they filled out the evaluations.

2.5 Anticipated Improvements

The authors have some ideas they hope will increase the depth of the students' reflection on their project experiences, and broaden the contexts in which the students articulate their knowledge. These ideas could be implemented in future offerings of the course.

We believe that presentations to fellow students would offer valuable opportunities to think through the issues in a semester-long project. Although the course curriculum prohibits the substantial sacrifice of class time that required in-class presentations would demand, Lafayette College has a tradition of lunchtime seminars that could accommodate these kinds of presentations. The groups would be offered several opportunities to make presentations and would be required to use at least one of them. On-campus publicity and a free lunch would supplement required class attendance and provide well-prepared presentations with diverse and fertile feedback.

Groups working on a service project would benefit from the additional experience of making a report to the partner CBO. The presentation to a general audience intimately familiar with the situation under study would demand careful interpretation of the results and their construction in language that is not statistically sophisticated. The students attempt to accomplish this in their

final written reports, but the opportunity for feedback from their intended audience would improve the final product.

3. OBSERVATION AND DISCUSSION

The authors continue to use service-learning as an option in statistics, and hope to improve the quality of all aspects of the experience: the quality of the service offered, the engagement and reflection of the students, and their mastery of the material.

The authors have observed opportunities to improve the syllabus highlighted by the service projects. They demonstrate the importance of developing the students' ability to assess the quality of data. Compensating for low response rates, incomplete responses, outliers, and uncooperative responders is not treated in the text for the course, but these issues are of real practical importance in analyzing and interpreting the data that students collect in service projects. The same issues come up in most of the statistical studies that students perform, but because the studies themselves are of only academic interest, the students are not as impressed with the importance of treating these problems well.

The change to a semester-long project made it easier to meet the goal of introducing students to the elements of statistical inference. As the foregoing example shows, not every service project entails an inferential component. However, every project offers the students the opportunity to consider which statistical tools are appropriate to their situation. During the course of the project, Root deliberately questions the students about the possibility of using basic inferential techniques (hypothesis tests or confidence intervals) to analyze the data. Thus, even those who do not apply inferential techniques must consider the utility of those techniques in the context of their project.

Rossman and Chance, in their guidelines for the teaching of inference (Rossman and Chance 1999) acknowledge that it is appropriate to "[s]tress the limited role that inference plays in statistical analysis." In the authors' experience, the realism offered by service projects more than compensates for the lack of a guaranteed application of statistical inference. This is entirely within the best practice for this sort of course as described by Bradstreet (1996), getting students "thinking about research issues in a statistically sound and practical fashion."

Practicality includes learning how to apply tests of significance that are not part of the syllabus. The students routinely read a section of their text and applied the significance test described there (the most common is the χ^2 test), using software to do the computations. Most groups made an office visit to cement their understanding, but having done so they were able to accurately apply the technique and interpret the results.

Service-learning projects in statistics are more work than "count the steps between the student union and the library" projects for the instructor as well as the student (Duke 1999, p. 796). Lafayette College is fortunate to have a community service office to establish relations with CBO's and identify service opportunities. Experiential education administrators or centers for teaching and learning can also be a great help in identifying community-based learning projects that are intellectually appropriate and manageable. The instructor has to actively work with the CBO to make sure that the project meets the educational goals of the class and is suitable for student work. Furthermore, the instructor should maintain frequent contact with the students to ensure that they are applying the techniques and principles they are learning accurately and appropriately. Once projects are completed, copies of the final reports (preferably graded copies) have to be sent to the CBO's. Their feedback demonstrates the value of the students' work and has motivated the authors to maintain a high level of effort.

Just as incorporating active learning can be torturous for instructors accustomed to lecture classes, moving to a service-learning pedagogy can be difficult. It is worth it. Students are more engaged, they are willing to examine nuances and difficulties that seem unimportant in a traditional textbook/lecture presentation and—as a result—we believe they learn the material more thoroughly and more lastingly. In a similar effort, Duke (1999) reached these conclusions as well.

The authors are also considering means of extending the service-learning dimension into other courses offered in the mathematics department. Two prospects are mathematical modeling and engineering differential equations. In any case, the service project will remain an option in our implementation. This follows from our desire to follow the dictum of "first, do no harm"; students who do not want to go off campus could have a terrible impact on the larger community. The authors do not wish to portray service-learning as a panacea for introducing an active dimension into the mathematics classroom. Moore, Cobb, and Garfield (1995) offered an interesting account of the difficulties of incorporating active learning in an upper-level undergraduate statistics course, and courses with more abstract subject matter are even less suited for a tool that demands practical application.

Eyler and Giles' (1999) recent overview of service-learning systematically evaluates claims of the sort that we make here and that form the core of the field. It seems to us that more thought should be given to what kinds of learning outcomes service-learning could achieve in the mathematical sciences. In general

> [s]ervice-learning aims to connect the personal and intellectual, to help students acquire knowledge that is useful in understanding the world, build critical thinking capacities, and perhaps lead to fundamental questions about learning and about society and to a commitment to improve both. Service-learning aims to prepare students who are lifelong learners and participants in the world (Eyler and Giles 1999, p. 14).

The authors embrace these goals as worthy, and add some of their own: Our desired learning outcomes include applying mathematical ideas in multiple contexts, using mathematics and statistics to make sense of one's personal experience, seeing the impact of the mathematical sciences on society, and, of course, mastering the material. We look forward to learning from others as they experiment with this pedagogy and discover connections between service and mathematics.

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