TEACHING UNDERGRADUATES THROUGH STATISTICAL CONSULTING

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Statistical consulting is a challenging and rewarding part of statistics. A consultant uses the art and science of statistics to solve practical problems. However, most consultants at universities and in industry have graduate degrees in statistics or are working on graduate degrees leaving undergraduates little opportunity to engage in this rewarding part of statistics. CASE (Center for Applied Statistics and Evaluation) is an undergraduate driven statistical consulting center. Students working with clients ranging from grant recipients to community organizations experience transformative, active, and civic engagement learning, as well as an experience similar to undergraduate research and internships. CASE can help students build a strong technical background in statistics, but more importantly provides the opportunity to build communication skills, common sense and a good business sense with faculty and peer mentoring.

INTRODUCTION

Statistical consulting is a challenging and rewarding part of statistics. A consultant uses the art and science of statistics to solve practical problems from many different fields, e.g. marketing, product design, manufacturing, medicine, agriculture, or genetics. (www.amstat.org/sections/cnsl)

Literature on statistical education suggests statistical consulting as a great education tool involving active learning, problem solving, communication, team work, and application to everyday situations. (Moore, 1997; Chatfield, 1995; Derr, 2000; Cobb, 1993; Taplin, 2007)

Many universities run statistical consulting services for researchers and students within their institution, and some also offer external consulting on commercial terms. However, most consulting services employ faculty or graduate students with some exceptions aiming more advanced undergraduate students. (Bentley, 1991; Jerkey, 2002; Taplin, 2003)

Truman's Center for Applied Statistics and Evaluation (CASE) was launched in January 2011, employing qualified students from a variety of majors in an outside of class setting with an emphasis on team structure and peer mentoring among its student consultants. While working as a consulting team, students learn both from faculty mentors and peer-mentors. The literature on student learning has established peer-mentoring as a powerful pedagogy, both for the student learning from his or her peers and for the student who is acting as a teacher and leader. This project purposefully implements this pedagogy (Jacob, 1991; Boisot, 1998; Hezlett, 2005; Bryant & Terborg, 2008).

CASE also serves as a focal point on campus for interdisciplinary activity involving statistics. "Students, especially undergraduates, are strongly attracted to interdisciplinary courses, especially those of societal relevance" (National Academy of Science, 2004). Over the last three years, CASE has grown, currently employing 17 students from 8 different majors in 4 different teams working on interdisciplinary activity in more than 40 institutional, grant and external projects. The CASE experience is well aligned with ASA-endorsed curriculum guidelines for undergraduate statistics programs, which call us to (1) emphasize real data and authentic applications, (2) encourage synthesis of theory, methods and applications, and (3) offer frequent opportunities to develop communication skills.

Student consultants can develop a strong technical background in statistics and good leadership and communication skills in a team environment. While solving a real life problem, they are fully engaged in their learning and often develop an enthusiasm about statistics. Our graduates have gone to graduate schools in the areas of statistics, biology, psychology, and biostatistics.

Center for Applied Statistics and Evaluation (CASE)

Student selection: Student applicants are selected through an interview process and placed on one of several student teams where they begin to work on practical problems in many fields.

Consulting team: A consulting team consists of four student consultants, including one senior consultant. Students with at least one year of consulting experience can apply to become a

senior consultant, the leader of a team. Senior consultants are in charge of managing projects and peer mentoring. Faculty mentors oversee any project that needs supervision.

Director, Associate Director, 2 Faculty consultants/mentors			
Senior consults.	Senior consults.	Senior consults.	Senior consults.
3 Junior consults.	3 Junior consults.	3 Junior consults.	3 Junior consults.

Consulting course (Introduction to Statistical Consulting, one credit)New in 2013 Fall: The first semester students receive training in various aspects of statistical consulting including project and time management, written and personal interaction with clients and use of appropriate statistical resources inside and outside of the class. With faculty and senior consultants mentoring, students participate in consulting projects involving research design, conducting statistical analysis and computing, writing a report, presentation, and communicating with clients.

Project categories: Consulting services vary to meet client needs: (1) Class support: drop-in hours for specific courses, and content area experts available for visiting classes and labs. (2) Quick consultations: One to three meetings with an individual consultant for a specific project, software training, or review. (3) Intermediate collaborations: For a larger research project involving data analysis and inference over several months, the faculty mentor will serve as the principal consultant, with as much work as possible done by student consultants. (4) Long term collaborations: For continuing research projects, including faculty and some external client projects lasting more than a year, a faculty mentor will serve as the principal consultant, with consultant teams working on smaller subprojects or components, as appropriate. (5) If the project requires skills beyond that of an existing consulting team, CASE will match the client with a faculty expert, who will use a consulting team for support and assistance, as appropriate.

Faculty role: Faculty consultants oversee most of the projects as principal consultants and are more closely involved with projects that require higher expertise. They are in charge of much of the initial and final stages of the project, meeting with clients, writing grant evaluation proposals, taking care of the financial side of the project, and handling confidentiality issues. Throughout the project, student consultants often communicate with clients and faculty and most of the work is done by student consultants. As the project approaches its final stage, faculty members are engaged with writing and editing.

Participant benefits: Serving as a consultant team requires several skills, which vary across projects, but typically include software mastery, speaking and writing skills, teamwork, time management, and good planning. Working from problem identification to end product production, students can develop statistical knowledge, communication skills, common sense and a good business sense. Particular development occurs in the following areas: (1) Interdisciplinary research: Working with real-world, interdisciplinary clients, students build connections between fields and learn about the differences in methods and perspectives. (2) Problem-solving development: Students work on unstructured problems that require building connections between current projects and previous knowledge learned in classes. (3) Community-based research and service learning: Students work with external clients from the community. Examples include a community center study, a daycare study, and a downtown building project. (4) Effective uses of technology: Consultants learn and use various statistical applications, including SPSS, MINITAB, SAS, and R.

SAMPLE PROJECTS

Oral Health Alliance (OHA) project: OHA is a three-year HRSA grant covering six counties in Northeast Missouri, with the aim of improving oral health in the area (Grant Number: D04RH23608, 2012-2014). This project promotes an awareness of dental health through creation of a webpage, brochures, and "tooth tests". It provides fluoride varnishes and information sessions to schools and head start programs. CASE gathers and analyzes data to monitor if they have met grant objectives and provides feedback on the progress of goals.

Building Development: A private developer purchased a block of property in downtown Kirksville and is interested in developing the property into a business that targets the student population. The client hired CASE to evaluate where student interest lies. We hosted a focus group for students, compiled the information from the focus group to design a survey, and administered

the on-line survey. We summarized the survey results and created a formal report. The client asked for feedback very quickly for business reasons and we finished the project in less than a month.

Residence life: Residential life at the university hopes to predict the number of beds needed for incoming students with information available at an earlier date. A multiple linear regression model was developed for the number of beds needed in early August, based on the number and demographic information of in-state students, out-of-state students and transfer students who have accepted their admission to the university as of January 31st.

CONSULTANTS SURVEY

In order to assess whether students were receiving the benefits we anticipate for a CASE experience, we administered a survey at the end of the spring semesters in 2012 and 2013. Student consultants were asked to rate the degree to which involvement in CASE improved their knowledge and skills in a number of areas related to more traditional undergraduate research experiences (e.g. as identified in Lopatto, 2003). They were also asked about skills related to professional development in Statistics. The results described below include all consultants who had worked at least one year with CASE at the time of the survey.

Results for proficiencies related to undergraduate research are shown in Table 1. Note that all but one of the proficiencies received at least 80% of ratings in the 4–6 range, indicating improvement. The category that dipped lower was "Learn to Use Literature."

Table 1. Student response to proficiencies related to undergraduate research

How much has working as a CASE consultant yielded benefits in each of these areas?	(Not at all) 0	1	2	3	4	5	(Very much so) 6	Median	*n*
Learn Topic in Depth	0.0	0.0	0.0	13.3	13.3	26.7	46.7	5	15
Construct Meaningful Problem	0.0	0.0	6.7	6.7	26.7	20.0	40.0	5	15
Apply Knowledge	0.0	0.0	0.0	0.0	0.0	0.0	100.0	6	15
Learn Methodology	0.0	0.0	0.0	0.0	6.7	46.7	46.7	5	15
Develop Proficiency	0.0	0.0	0.0	0.0	0.0	26.7	73.3	6	15
Think/Work Independently	0.0	0.0	0.0	0.0	6.7	20.0	73.3	6	15
Design Solutions	0.0	0.0	0.0	0.0	6.7	20.0	73.3	6	15
Analyze Data	0.0	0.0	0.0	0.0	0.0	6.7	93.3	6	15
Improve Oral Communication	0.0	0.0	0.0	13.3	53.3	33.3	0.0	4	15
Improve Written Communication	0.0	0.0	0.0	7.1	14.3	50.0	28.6	5	14
Appreciate What Researchers Do	0.0	0.0	6.7	0.0	6.7	26.7	60.0	6	15
Learn What Research Entails	0.0	0.0	0.0	0.0	20.0	26.7	53.3	6	15
Develop Orientation to Future Work	0.0	0.0	0.0	13.3	20.0	13.3	53.3	6	15
Clarify Career Goals	0.0	0.0	0.0	13.3	33.3	13.3	40.0	5	15
Learn to Use Literature	0.0	6.7	13.3	26.7	20.0	26.7	6.7	4	15
Contributing to Body of Knowledge	6.7	0.0	6.7	6.7	26.7	26.7	26.7	5	15
Learn How Research Builds on Preceding Research	0.0	0.0	6.7	13.3	20.0	33.3	26.7	5	15
Make Connections to Courses	0.0	0.0	0.0	0.0	6.7	26.7	66.7	6	15
Find a Faculty Mentor	0.0	0.0	0.0	0.0	6.7	13.3	80.0	6	15

Table 2 shows results for skills related to professional development in Statistics. Ratings are more varied in these categories, but in all cases the median rating is 4 or more. The one-credit statistical consulting course was created in 2013, in part, to specifically address student consultant training in many of these areas.

While one must be careful in interpreting self-reported data, we believe the results indicate that CASE is creating an experience with benefits similar to those of undergraduate research and that continued work to quantify and improve the CASE experience is worthwhile.

Table 2. Student response to professional development in statistics

How much has working as a CASE consultant allowed you to improve in these broad skills?	(No improve-ment) 0	1	2	3	4	5	(Very large improvement) 6	Median	*n*
Interaction and Communication	0.0	13.3	6.7	13.3	20.0	40.0	6.7	4	15
Data Collection and Interpretation	0.0	0.0	0.0	13.3	6.7	20.0	60.0	6	15
Professional Development	0.0	0.0	0.0	13.3	6.7	53.3	26.7	5	15
Personal Development	0.0	0.0	0.0	13.3	40.0	33.3	13.3	4	15
Design and Hypothesis Generation	6.7	13.3	6.7	6.7	13.3	40.0	13.3	5	15
Professional Advancements	0.0	0.0	6.7	13.3	13.3	46.7	20.0	5	15
Information Literacy	0.0	6.7	6.7	26.7	13.3	33.3	13.3	4	15
Responsibility and Ethics	0.0	0.0	20.0	13.3	20.0	26.7	20.0	4	15
Knowledge Synthesis	0.0	6.7	6.7	0.0	33.3	26.7	26.7	5	15
Computer Skills	6.7	0.0	13.3	20.0	13.3	33.3	13.3	4	15
Teamwork and Collaboration	0.0	0.0	13.3	0.0	0.0	66.7	20.0	5	15

CONCLUSION

Undergraduate students from various majors work with clients from various venues dealing with real data and authentic applications in CASE. They are encouraged to think of the "best" solution to unstructured problems and develop good communication skills in a team environment. They are fully engaged in their learning and develop an enthusiasm about statistics and their career development with statistics. This active learning experience is often transformative and similar to undergraduate research and an internship experiences. Our graduates have gone to top graduate schools in many areas, including statistics, biology, psychology, and biostatistics.

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